Table 33.—Wood energy production and consumption in the United States, by wood source and end user, specified years 1952–86.

Sector	1952	1962	1970	1976	1980	1981	1983	1984	1986
					Million cubic feet				
Production of roundwood fuelwood for all users									
Merchantable stem of growing stock trees on timberland	965	517	311	334					798
Other trees/sources	1,042	606	227	267					2,316
Total	2,008	1,123	538	601					3,114
Consumption of roundwood and mill residue in homes									
Merchantable stem of growing stock trees on timberland[1,2]					559				
Other trees/sources and logging residue[1,2]					2,544				
Mill residue[1,2]					223				
Total[1]					3,326	3,406		3,881	3,382
Mill residue use for fuel									
Wood residue (excludes bark)	2,486	900	727	752					1,400

[1]*Volume in cords times 79.2 cu. ft. per cord.*
[2]*Mill residue fraction in 1980 is 3.0/44.8, growing stock fraction of remainder is 18% (Skog and Watterson 1986).*
Sources: Production: 1952—USDA FS 1958; 1962—USDA FS 1965; 1970—USDA FS 1973; 1976—USDA FS 1982. Consumption: 1980—Skog and Watterson 1986; 1981—USDE EIA 1984; 1984—USDE EIA 1986.

Table 34.—Roundwood, and wood and bark residue consumption in the United States, by end user, specified years 1977–86.

Sector	1977	1980	1983	1984	1986
			Million cubic feet[1]		
Residential		3,326	3,722	3,881	
Wood products industry			1,650		
Pulp and paper industry					
Hog wood	311	433	783	828	923
Bark	320	366	418	432	469
Nonforest products industry			184		
Commercial buildings			80		
Utilities			9		
Total			6,846		

[1]*Assumes 32.6 pounds of wood per cubic foot.*
Sources: Residential: see source note table 33; wood products industry: Goetzl and Tatum 1983; pulp and paper industry: American Paper Institute 1987b; nonforest products industry, commercial buildings, and utilities: USDE EIA 1984.

nonresidential buildings, and electric utilities account for 4% of the total.

Residential

Residential fuelwood use, which had been declining for many years, began to rise after 1973 as the price of electricity, fuel oil, and natural gas increased (fig. 18; USDE 1985d, 1987). Studies show that between 1950 and 1973, the estimated number of wood-burning stoves in U.S. homes dropped from 7.3 million to 2.6 millon units. In the late 1970s, however, stove shipments increased by 1.0–2.5 million units per year and the inventory grew to an estimated 11 million in 1981 (USDE 1982). Other estimates indicate as many as 14 million stoves and fireplace inserts in homes in 1981 (Skog and Watterson 1986). These trends in wood-burning stove inventories suggest a four-fold rise in residential fuelwood use during the 1970s and early 1980s.

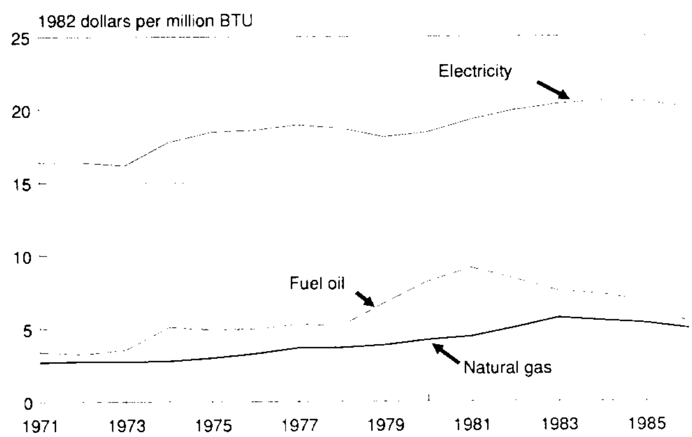


Figure 18.—Residential electricity, fuel oil, and natural gas prices, 1971–1986.

Surveys of consumers indicate that residential fuelwood use had increased to 3.3 billion cubic feet by

1980–81 and that it increased further to a peak of 3.9 billion in 1984, but subsequently declined to 3.4 billion in 1986. Similar trends were shown by fuelwood harvests—largely for residential use—from the national forests, which increased sharply to 5.1 million cords in 1982, before dropping to 2.1 million in 1986 (Paulson 1987). These trends largely paralleled the rise in the real prices of electricity, fuel oil, and natural gas and their declines in the mid-1980s (fig. 18, USDE 1987).

In the early 1980s, 28% of all U.S. households burned wood, averaging 1.8 cords each. However, wood use was much more common in rural areas. For example, 45% of all rural households burned wood and average annual use was 2.7 cords, whereas only 23% of urban households, many using fireplaces, burned 1.4 cords each (Skog and Watterson 1986). By 1984, about 27% of all households, rural and urban, are estimated to have used wood as a primary or secondary heating fuel (not including some esthetic fireplace use) for an average of 2.1 cords (USDE 1986).

Although households use both roundwood and mill residue for fuelwood, roundwood accounts for more than 90% of the total; and about three-fourths of all roundwood consumed by households is cut by household members (Skog and Watterson 1986). About one-fourth of all roundwood cut by households came from merchantable stem portions of growing stock trees on timberland. The remainder was from other sources including dead trees, cull trees, noncommercial species, or from nonforest lands, such as fence rows and urban tree trimming. In 1986, 82% of the roundwood harvested for fuelwood was hardwood species (Waddell et al. 1989: table 30).

The 3.3 billion cubic feet of fuelwood burned by households during the 1980–81 heating season contributed 0.8 quads of gross energy or about 9% of the total gross energy of all nonwood fuels used. The average efficiency of converting fuelwood to heat in stoves and fireplaces, however, is less than half the heat-conversion efficiency for electricity, fuel oil, and natural gas—30% versus more than 60%. As a consequence, the actual residential fossil fuel displaced by fuelwood was only 2 to 3% of the total used (Skog and Watterson 1986).

Industrial

Almost all of the 1.4 billion cubic feet (20.7 million bone dry tons) of wood residue (table 33) and the 17.6 million tons of bark from primary wood processing plants that was used for fuel in 1986 was burned to make steam, heat, or electricity in wood products mills and to a lesser extent, by nonforest products industries and commercial buildings. And the use of primary processing residues has been rising in recent years. For example, in 1970 about 25% of all primary wood and bark residues was used for fuel (Grantham and Howard 1980); by 1986, 41% of the total was used (Waddell et al. 1989: table 31). This increase may, in part, be due to the effects of the Public Utilities Act of 1978 which encourages businesses to generate and sell excess electricity made from renewable resources to electric utilities.[8]

The use of wood and bark residue for energy by the solid-wood products industries grew fairly rapidly during the 1970s, rising from 19.4 million oven dry tons in 1970 to 26.9 million in 1981 (Goetzl and Tatum 1983). In addition, during the latter year a small amount of roundwood—13,700 tons—was used for space heating. By 1981, 70% of the solid-wood products industries' total energy requirements were obtained from wood-derived fuels.

For the pulp and paper industry, it is estimated that wood and bark used for energy increased from 8.7 million oven dry tons in 1972 to 24.7 million in 1986 (American Paper Institute 1987b) and the use of spent pulping liquor grew from 62.2 million to 81.3 million tons over the same time period. Pulp and paper mills obtained about 40% of their energy requirements from residues or spent liquor in 1972; 57% in 1986.

Although their consumption is far smaller, industries producing other than primary wood-based products also use wood-derived fuels for energy production. Studies of eight major groups of industries producing a wide range of nonwood products indicate a combined total use of 3 million oven dry tons of roundwood and residues in 1983 (USDE 1984).[9]

Commercial Buildings

In addition to residential and industrial fuelwood consumption, an estimated 1.3 million oven dry tons of wood-derived fuel was used in commercial buildings in 1983 (USDE 1983).[10] Wood consumption in commercial buildings also increased in the early 1980s. For example, in 1980, 2.9% of all commercial buildings used wood as fuel; by 1983 about 3.4% burned wood (USDE 1983, 1985b). Although the incidence of wood use increased fairly rapidly over the 3-year period (by 1983 about 134,000 buildings burned wood), the impact on total fossil fuel use was somewhat less than the rise in the number of wood-burning buildings would seem to indicate. The average size of buildings using wood in 1983 was only about 6,400 square feet, while the average for all commercial buildings was almost 12,000 square feet. Moreover, less than half of the commercial buildings using wood were as large as 3,000 square feet.

[8]*The Public Utilities Regulatory Policies Act of 1978 requires electric utilities to buy electricity generated by renewable resources at a rate equal to their full avoided cost of production (USDE 1985c).*

[9]*In addition to the lumber and wood products and paper and allied products industries, industry groups studied include textile mill products; furniture and fixtures; chemicals and allied products; stone, clay, and glass products; food and kindred products; printing and publishing; petroleum and coal products; and rubber and miscellaneous products.*

[10]*For the study from which these data are derived, commercial buildings include nonresidential buildings except those where industrial activities occupy more square footage than any other activity. The types of commercial buildings included in the study are those used for the assembly, sales and service of automobiles, education, food sales, health care, lodging, offices, residential (but with some commercial activity), retail/sales, and warehouse/storage.*

Electric Utilities

One of the major uses of fossil fuels in the United States is for the generation of electricity in steam-electric facilities. As a result of the rise in fossil fuel prices in the 1970s there was much interest expressed in the increased use of wood and wood residues for this purpose. In 1983, there were 9 utilities producing electricity and using about 150,000 oven dry tons of wood and wood residue annually. Although consumption fluctuated somewhat, this was only slightly larger than the 141,000 tons used in 1973 (USDE 1982). By 1985, there were only 8 wood-using utilities active, and their total production of electricity was about 130 megawatts (USDE 1985a).

Energy Plantations

With practices similar to those used in modern agriculture, intensively cultivated plantations of fast-growing trees can produce as much as 10 tons per acre (dry basis) per year of wood, bark, and foliage. The possibility of establishing such plantations on a scale large enough to provide a steady source of fuel for steam-electric utilities, or raw material for chemical conversion to liquid fuels, received much attention from scientists and policymakers in the late 1970s (USDA FS 1982). The Short Rotation Woody Crops Program begun by the U.S. Department of Energy in 1977 has made progress toward its goal of developing technology to grow and deliver woody biomass at prices competitive with the lowest-cost fossil fuel, coal (Ranney et al. 1985, 1986). Average growth rates for promising species on various sites range up to 6.7 dry tons per acre per year (Klass 1986).[11] At the current time, it appears that coppicing and high speed harvesting systems are essential to keep overall costs low.

TIMBER CONSUMPTION SUMMARY

The consumption of timber products discussed in this chapter has been shown in standard units of measure; that is, board feet of lumber, square feet of panel products, cords of pulpwood and fuelwood, and cubic feet of miscellaneous industrial roundwood products. In order to compare consumption of these products with timber supplies, these various units must be converted to common units of measure—cubic feet of roundwood.

Improvements in Utilization

In recent decades, primarily in response to increasing costs of stumpage, there have been large improve-

[11]*Species showing promise in various regions include* Eucalyptus grandis, Eucalyptus saligna, Populus deltoides, Populus trichocarpa, Populus *spp. hybrids, and* Robina pseudoacacia.

Table 35.—Roundwood consumption in the United States, by softwoods and hardwoods, and product, specified years 1952–86.

Species group and product	1952	1962	1970	1976	1986
	Billion cubic feet, roundwood equivalent				
Softwoods					
Saw logs	5.0	4.8	5.0	5.7	7.4
Veneer logs	.2	.7	.9	1.3	1.5
Pulpwood[1]	2.4	2.6	3.4	3.3	3.8
Miscellaneous products[2]	.3	.2	.2	.2	.3
Fuelwood	.5	.2	.1	.1	.5
Total[3]	8.4	8.5	9.7	10.7	13.5
Hardwoods					
Saw logs	1.1	1.3	1.2	1.3	1.7
Veneer logs	.2	.2	.3	.3	.2
Pulpwood[1]	.3	.7	1.0	1.1	1.6
Miscellaneous products[2]	.4	.2	.2	.1	.2
Fuelwood	1.5	.9	.4	.5	2.6
Total[3]	3.5	3.3	3.1	3.3	6.3
Total, all species					
Saw logs	6.1	6.0	6.2	7.0	9.1
Veneer logs	.4	.9	1.2	1.5	1.7
Pulpwood[1]	2.7	3.3	4.4	4.4	5.3
Miscellaneous products[2]	.7	.6	.4	.4	.5
Fuelwood	2.0	1.1	.5	.6	3.1
Total[3]	11.9	11.9	12.7	14.0	19.8

[1]*Includes both pulpwood and the pulpwood equivalent of the net imports of pulp, paper, and board.*
[2]*Includes cooperage logs, poles, piling, fence posts,round mine timbers, box bolts, shingle bolts, roundwood used in waferboard, oriented strand board, and particleboard manufacture, and other miscellaneous items.*
[3]*Includes imported logs not shown by product use.*
Note: Data may not add to totals because of rounding.

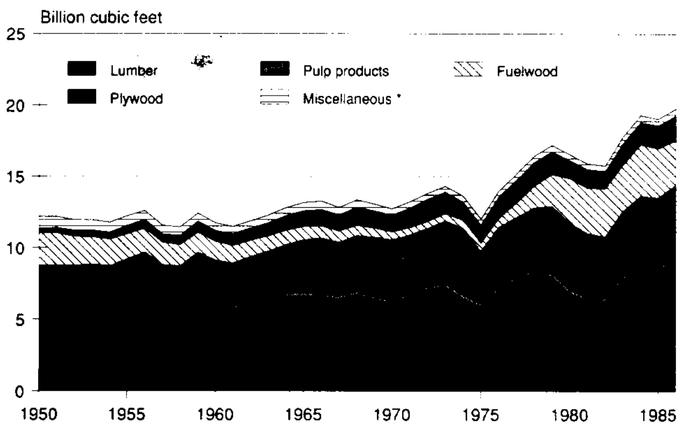
ments in converting the timber harvested from the Nation's forests into the various wood products. These improvements, discussed in detail in Chapter 10, have involved increasing use of slabs, edgings, sawdust, veneer cores, shavings, and other wood processing byproducts for pulp, particleboard, and similar products. In addition, various technological developments such as thinner saws, computer-controlled head rigs, and innovations such as best opening face in the lumber industry; and powered back-up rolls, spindle-less lathes, and automated handling systems in the plywood industry have led to increased product yield per unit of wood input. To some extent these improvements have been offset by other changes such as the use of smaller and lower quality material, and the use of the chipping headrig for lumber production. Nevertheless, the overall increases in conversion efficiency have been substantial.

Roundwood Consumption

In 1986, total U.S. consumption of timber products in terms of roundwood volume was 19.8 billion cubic feet (table 35, McKeever and Jackson 1990: A-14, and fig. 19). This is 41% above consumption in 1976, and the peak in a trend that—with some variation—has been increasing since the early 1960s. Roundwood consumption in 1986 was also materially above the levels attained in the early 1900s when lumber and fuelwood were the principal building and heating materials used in the United States.

About 46% of the roundwood consumed in 1986 was saw logs, 27% pulpwood, 16% fuelwood, and the remainder veneer logs and miscellaneous products. This was quite different than in the 1970s when roughly half of the total was saw logs, one-third pulpwood, and less than 5% fuelwood. Although consumption of all of the roundwood products rose between 1976 and 1986, a large part of the overall growth was due to the rapid rise in fuelwood consumption.

Growth in roundwood consumption in the 1950s, 1960s, and early 1970s consisted entirely of timber from softwood species, as hardwood roundwood consumption fell in response to declines in use of miscellaneous industrial timber products and fuelwood (McKeever and Jackson 1990: tables A-15 and A-16). In the mid-1970s softwoods accounted for more than 76% of total consumption. This trend was reversed in the late 1970s, however, largely due to the relatively more rapid increases in hardwood use for pulpwood and fuelwood, and in 1986 softwoods accounted for only about 68% of total roundwood consumption (fig. 20).



* Includes imported logs.

Figure 19.—Roundwood consumption, by product, 1950–1986.

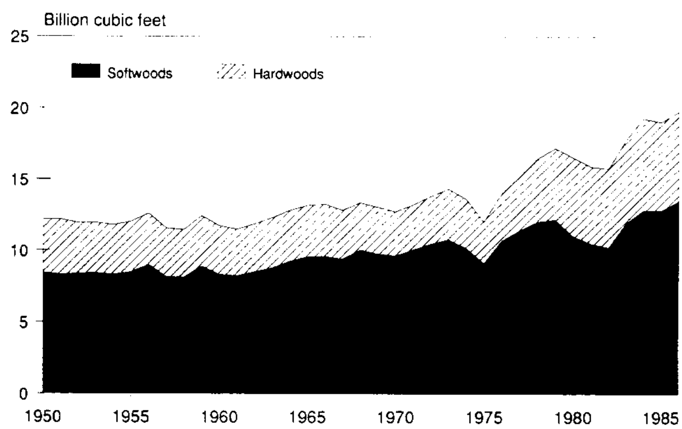


Figure 20.—Roundwood consumption, by species group, 1950–1986.

CHAPTER 3. DOMESTIC TIMBER RESOURCES

The timberlands of the United States and the forests that grow thereon are an important, diverse, and dynamic resource. In 1985, this resource produced 14% of the world output of industrial roundwood (United Nations Food and Agriculture Organization 1986b). The Nation's timberlands, which are found in every state, support many different tree species—both hardwoods and softwoods. These domestic timber resources provide essentially all of the wood raw material consumed by the Nation's primary wood processing industry.

These timber resources are in a state of perpetual change. There are changes in the timberland area base due to conversion or dedication to other uses, and due to planting or tree seeding of areas formerly not forested. The forests are dynamic, living resources, undergoing a continuing process of birth of new trees, growth of existing trees, and loss of trees through mortality or harvest for conversion to wood products. In the last decade, the Nation's timberland area has decreased slightly (1.6%). During the same period, timber volume on those lands increased 4%, and timber growth increased 3%. In 1986, removals of timber—mostly in the form of harvest for wood products—was 16% more than reported for 1976. This overall picture of a relatively stable resource situation for the Nation's timber resources masks many regional and local changes in the timber resources and timber outputs. This chapter provides a general discussion about the nature and extent of the Nation's timber resources, and how they have changed in the last decade. Included are discussions about the timberland area base characteristics, including location, ownership, and productive potential. There is also a characterization of the timber resources found on these lands—species composition, timber volumes, and the elements of change (growth, mortality, and timber removals).

The focus of this chapter is the national timber situation, but considerable discussion is directed to four major sections of the country—North, South, Rocky Mountains and Pacific Coast (see back cover for a map). Detailed regional and state level statistics for the Nations's timberland resources are provided in Waddell et al. 1989. The data supporting this chapter were derived from the periodic forest inventories conducted by the regional Forest Experiment Stations and the Forest Service Administrative Regions.

FOREST LAND AREAS

Forests occupy approximately one-third (731 million acres) of the Nation's land area (table 36). The forests are found in every section, region and state. They vary tremendously, from sparse scrub forests of the arid interior west, to the highly productive forests of the Pacific Coast and the South, and from pure hardwood forests to multispecies mixtures, and coniferous forest.

Two-thirds of the Nation's forests are timberland, forests capable of producing 20 cubic feet per acre of industrial wood annually and not reserved from timber harvest. An additional 35 million acres of timberland, reserved for nontimber uses, is managed by public agencies as parks or wilderness areas.

In addition to the timberlands, there are 213 million acres of other forest land not capable of producing 20 cubic feet of industrial wood annually, but of major importance for watershed protection, wildlife habitat, domestic stock grazing and other uses. Almost all of the other forest land is in the West; over half is in Alaska.

Rain or shine, trees or stumps, our forest inventory goes on.

Table 36.—Land area of the United States, by section and type of land, 1987.

Type of land	Total United States	North	South	Rocky Mountains	Pacific Coast
			Million acres		
Total forest land	731.4	165.5	203.5	142.3	220.1
Timberland	483.3	154.7	195.4	61.1	72.1
Timberland, reserved	34.5	6.7	3.0	12.0	12.9
Other forest land	213.5	4.1	5.1	69.2	135.1
Other land	1,526.2	247.2	330.9	598.3	349.6
Total land area	2,257.6	412.7	534.4	740.7	569.8

Although the other forest lands produce little industrial roundwood, they do produce other wood and tree products which are often important for local use. Fuelwood is a primary use in many areas having nontimber forests, such as the oak woodlands of California and the pinyon-juniper forests of the Southwest.

Timberland Area

Though found in abundance in all regions of the country, the Nation's timberlands are concentrated in the eastern part of the United States. Much, if not most, of the eastern United States was forested before settlement, and although much timberland has been converted to nonforest use, timberlands remain a dominant feature of the landscape. Seventy-two percent of the Nation's timberlands are in the eastern United States.

The West, characterized in part by vast plains and interior basins, and the tundra of interior Alaska, was not predominately forested upon first habitation. And timberlands are now, as in the past, a minor part of the total forest area in the West, although timberland does constitute more than half of all forest land in Oregon and Washington in the Pacific Northwest region, and Colorado, Montana, and Idaho in the Rocky Mountains (table 36, Waddell et al. 1989: table 1).

Timberland Ownerships

Timberland ownership patterns vary throughout the United States. For descriptive and analytical presentation, timberland ownership has been divided into four broad classes: national forests; other public; forest industry; and farmer and other private. Private lands are concentrated in the eastern part of the country; public lands in the West (fig. 21). For the United States as a whole, 72% of all timberlands are owned by private individuals and firms; federal, state, and other public owners account for the remaining 28%. The balance between public and private has not appreciably changed since 1977 (USDA FS 1982).

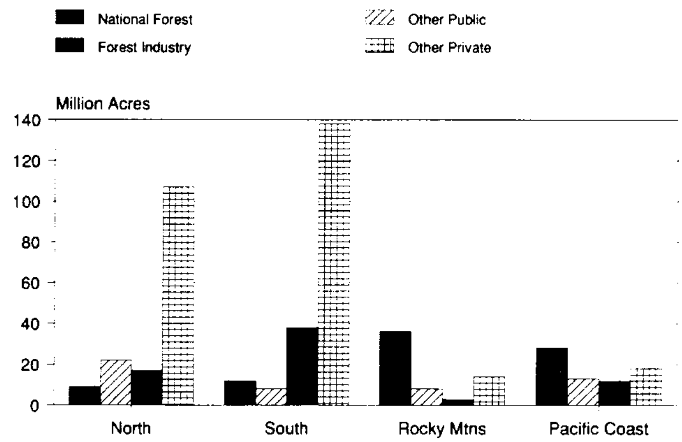


Figure 21.—Area of timberland in the United States, by section and ownership, 1987.

Farmer and other private.—Timberlands in this owner group include individuals, trusts, and corporations. In total, owners in this group probably number in the millions, and represent the diversity of the Nation. Private forest industry holdings are excluded from this broad owner class.

Not surprisingly, this owner group accounts for most (57%) of the timberland area in the United States. Within this broad owner class, the largest identifiable group are farmers, who control 97 million acres, 20% of all timberland in the United States.

Farmer and other private timberlands are concentrated in the eastern sections of the country; 88% of all such land is found in the North and South, accounting for about 70% of all timberland in both areas. In contrast, in the Rocky Mountain and Pacific Coast sections, this owner group accounts for about one-quarter of all timberlands.

Farmer and other private ownerships include many small parcels, and a smaller number of large tracts of land. The forested parcels in this owner group are found near urban areas, intermingled with cultivated land or land of other nonforest uses, as well as in remote areas. Many different management objectives are held among the owners of this group; at any given time some of the area is not available for the production and harvest of timber. But ownership of timberland is transitory in this group as are individual owner's objectives; changes in ownership and objectives often bring formerly unavailable resources into the market. These timberlands continue to be extremely important to the health of

Using topographic maps to determine acreage of area to be sampled. In forest inventories, for every person-day spent in the woods, an additional day is required for map work, aerial photo interpretation, ownership collection, and related office preparations.

timber economies and to the users of wood products; nowhere is that more evident than in the South.

Forest industry.—Forest industry timberland holdings in the United States total over 70 million acres. These timberlands are owned by operators of primary wood products manufacturing facilities. They have historically been treated as an identifiable owner group because—unlike the farmer and other private group—they are thought to have common objectives for ownership and management of timberland. Most of the forest industry timberland is in the eastern United States; 54% of all such lands are in the South; 24% are in the North, primarily in the Northeast Region. The Pacific Coast has 18% of all industry timberlands, the Rocky Mountain section only 4%. The location of forest industry timberlands has been strongly influenced by the location and availability of highly productive forest land. The importance of these timberlands as a continuing source of wood raw material far exceeds what their proportional area indicates.

National forest.—National forest timberlands in the United States total 85 million acres or 18% of all timberlands. Because national forests were created from unclaimed public lands around the turn of the century, most national forest timberlands are in the West (75%). By the time of selection, much of the more accessible, highly productive forested area was no longer in the public domain. As a consequence, national forest timberland is, on average, of lower productivity and on steeper, higher elevation terrain than are private timberlands.

Other public.—This owner group includes all public owners other than national forest. Included are lands administered by the Bureau of Land Management, lands administered in trust for Native Americans by the Bureau of Indian Affairs, and state, county, and municipal lands. Timberlands in this owner group account for almost 11% of all timberlands. State-owned timberlands, of which every state has some, account for over half of the timberland area in other public ownership (Waddell et al. 1989: table 2).

The largest concentration of other public timberland is in the North (42% of the nationwide total). Pennsylvania in the Northeast Region and Michigan, Minnesota, and Wisconsin in the North Central Region all have large concentrations of other public timberlands. In these regions, timberlands which reverted to the states through tax delinquency during the depression account for much of the other public ownership. In the West, Oregon, Washington, and Alaska have large acreages of other public timberland—mostly state land in Alaska and Washington, and Bureau of Land Management (BLM) land in Oregon.

Forest Types of the East and West

The timberlands of the United States span a wide range of latitudes, elevations, precipitation, and soils. As a consequence the species composition of the forests found on these timberlands is quite diverse, ranging from pure stands of ponderosa pine in the semiarid west to the complex multispecies hardwood forests of the Northeast.

Eastern hardwood forests.—The eastern hardwood forests in total account for 52% of the timberland area of the United States, and 72% of the timberland area in the East. This group of multispecies types covers the majority of timberland in all four eastern regions—North Central, Northeast, South Central, and Southeast. The most wide spread forest type is oak-hickory, which is found throughout the South and the southern half of the North; timberlands in this type total 118 million acres (table 37).

The oak-gum-cypress forests, which total 28 million acres, are the mainstay of the southern hardwood industry. Although much of this forest type has been lost through conversion of bottom lands to agriculture, it appears that the acreage has stabilized in recent years.

Elm-ash-cottonwood forests are bottomland forests of the North and South. They account for 14 million acres, mostly in the North Central and Northeast regions. White ash from these forests is used for a number of specialty wood products.

Maple-beech-birch forests are found on 44 million acres of timberland in the Northeast and North Central regions. These forests, which have expanded in acreage in recent years, contain a number of prized hardwood species, including sugar maple and the birches. This is the forest type famed for fall color. Most of the 18 million acres of aspen-birch forests are in the North Central region. This forest type is made up of pioneer species that often take over areas following disturbance or removal of other forest types. This type is a major source of fiber for the pulpwood industry in the North.

Table 37.—Area of timberland in the United States, by forest type, 1987.

Forest type	Area
	Million acres
Eastern types	
Softwood Types	
Loblolly-shortleaf pine	48.6
Longleaf-slash pine	15.5
Spruce-fir	16.8
White-red-jack pine	13.9
Total	94.8
Hardwood Types	
Oak-hickory	117.7
Oak-pine	31.3
Oak-gum-cypress	28.1
Maple-beech-birch	44.2
Elm-ash-cottonwood	14.3
Aspen-birch	17.8
Total	253.4
Non-stocked	5.5
Total, East	353.7
Western types	
Softwood Types	
Douglas-fir	32.6
Ponderosa pine	24.6
Fir-spruce	26.9
Lodgepole pine	11.6
Hemlock-sitka spruce	11.0
Larch	2.6
White pine	.3
Redwood	1.1
Other western softwoods	.8
Total	111.5
Western hardwoods	15.8
Non-stocked	2.4
Total, West	129.7
Total, United States	483.3

The oak-pine forests of the East are found primarily in the South. Many of these stands on Southern timberlands have emerged following selective harvesting of natural pine forests. The acreage in this type has declined almost 10% in the last decade, due to conversion of these forests to pine forests for the production of softwoods.

Eastern softwood forests.—The eastern softwood forests, though occupying a much smaller area of timberland than the hardwood forests, are the most important timber production forests throughout much of the East. Nowhere is this more true than in the pine region of the South. In both the southeast and southern regions, the longleaf-slash pine and loblolly-shortleaf pine forests, which combined account for 64 million acres of timberland, provide the raw material for the South's huge and still growing forest products industries. The loblolly-shortleaf pine forests account for over half of the 95 million acres of conifer-bearing timberlands in the East.

Longleaf-slash pine forests, which account for less than one-quarter of the southern pine type acreage, are found in states bordering the South Atlantic and Gulf coasts, but most of the area in this type is concentrated in Florida and Georgia.

The white-red-jack pine and spruce-fir forests are the softwood forests of the North. Combined, they account for one-third of the softwood forests of the East, but only 6% of all of the Nation's timberlands. The spruce-fir forests of the Northeast are an important source of pulpwood in that region.

The white-red-jack pine forests total 14 million acres. The species composition of this forest type varies; in the Northeast, white pine predominates, while red and jack pines are the common pines of the North Central region.

Western forests.—The timberlands of the West are forested primarily with softwood species. Eighty-six percent of the timberland area in the West is forested with softwoods; 12% has hardwood stands, and 2% is currently nonstocked.

Three forest types account for two-thirds of the forests on the West's timberlands. The Douglas-fir type, which is found in the Rocky Mountains, and in the Pacific Northwest and Pacific Southwest regions, totals 33 million acres, and is the most abundant and important species in the West. The Douglas-fir forests on the Pacific slope in the Northwest are perhaps the most productive softwood forests in the United States. Ponderosa pine forests occupy about 25 million acres of timberland in the West, over 55% of which is in the Rocky Mountains. This species is also abundant east of the Cascade Range in the Northwest region, and in California. The ponderosa pine forests of the West are a major source of raw material for the manufacture of lumber. The fir-spruce forests are found on 27 million acres of western timberlands. These forests, found at medium to higher elevations throughout the forested West, have gained in value and use for wood products in recent decades, with tightening supplies for other species. The area of fir forests has increased in some areas such as California, due in part to selective harvesting of pine in mixed conifer stands.

Hemlock-sitka spruce forests are found primarily on the Pacific slope in Oregon and Washington, and in coastal Alaska. These forests account for about 8% of the West's timber forests, and are important timber species, providing raw material for lumber products, pulping, and log export on the Pacific Coast.

Lodgepole pine is another significant forest type on western timberlands. Lodgepole stands total almost 12 million acres. Although present throughout much of the West, this species is most abundant in the Rocky Mountains; it is present in significant quantities in the ponderosa pine subregion of the Northwest.

The other western softwood types—larch, redwood, western white pine, and other minor species—total less than 5 million acres, and are much more localized in occurrence and importance than the major forest types of the West.

There are about 16 million acres of hardwood forests on western timberlands. In California, oaks predominate in hardwood stands; in the Rocky Mountains, aspen is the most abundant hardwood. In the Northwest Region, red alder is the most abundant hardwood species. In recent years this species has increased in area, volume, and value to the wood products industry. It is currently used for fuelwood, lumber and specialty millstock, and pulp chips for both domestic use and export.

Forest inventory data collector in a western hemlock stand entering tree and understory vegetation data into a portable electronic recorder.

Timberland Productivity

Timberland productivity is sometimes measured in terms of the maximum amount of wood that can be produced annually in fully stocked natural stands of timber. It is a measure of potential, not of what the land is currently producing. An assessment of inherent productivity of timberlands provides a basis for comparison of timberlands in different regions and sections of the country. Although it gives some indication of what could be produced, were all timberlands fully stocked at all times with natural stands, this measure of productivity does not consider the increases in yields that could be expected with active management of plantations for timber production. Millions of acres of timberland in the United States produce in excess of the estimates included in this discussion because of active management to increase yields and use of genetically improved planting stock.

Forest lands that cannot produce 20 cubic feet of wood annually are not considered timberland, due to the nature and slow rate of growth of the trees that are generally found on such lands. There are 203 million acres of such forests in the United States, areas potentially available for harvest of trees, but not capable of producing crops of industrial wood. Fir-spruce forests in interior Alaska and pinyon-juniper forests in the Rocky Mountain Region together account for 112 million acres of these forests with low potential for industrial wood product production (Waddell et al. 1989: table 5).

Recent inventories of timberlands throughout the United States indicate that 11% of the Nation's timberlands can produce in excess of 120 cubic feet of industrial roundwood per acre annually. The South—largely the loblolly-shortleaf pine, oak-pine, oak-hickory, and oak-gum-cypress forests in the South Central Region—accounts for 45% of these highly productive timberlands (fig. 22). The Pacific Coast has 37% of these timberlands, although accounting for only 15% of the Nation's total timberland area. The Douglas-fir, hemlock, and red alder stands in the Douglas-fir subregion, and redwood and fir stands in California are among the most productive forests in the West.

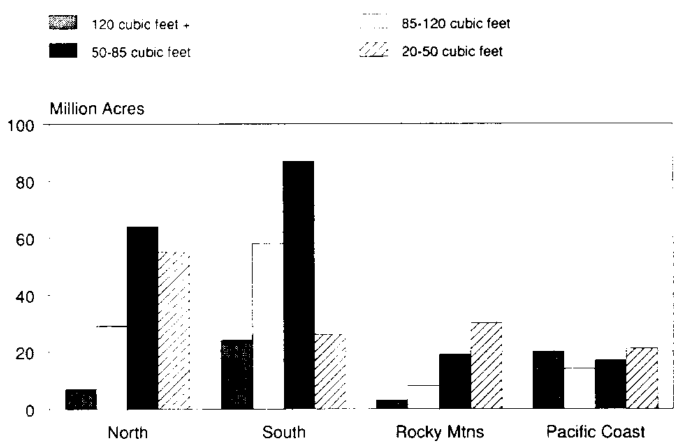


Figure 22.—Area of timberland in the United States, by section and productivity class, 1987.

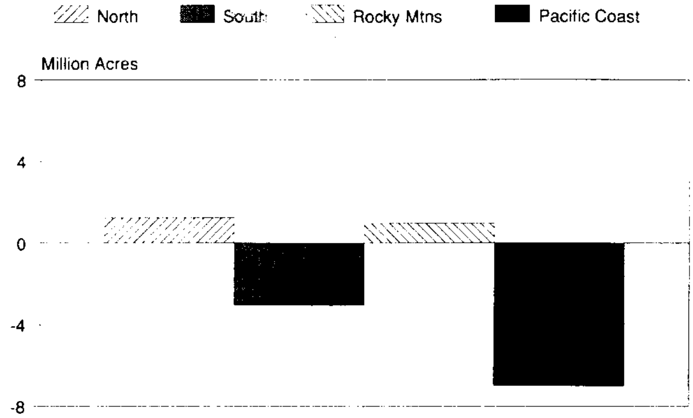


Figure 23.—Change in timberland area by section, 1977-1987.

There are 110 million acres capable of producing 85 to 120 cubic feet; 53% of this area is in the South, forested by the same species that are found on the higher productivity lands. The North accounts for 26% of the 85 to 120 cubic foot potential timberland; oak-hickory, maple-beech-birch, and aspen-birch account for much of the northern acreage in this productivity class.

Although discussion usually focuses on the most highly productive timberlands, two-thirds of the Nation's timberlands do not have the capability to produce 85 cubic feet per acre annually; 39% of all timberland area has the capacity to produce 50 to 85 cubic feet annually; 27% has the capacity to produce 20 to 50 cubic feet. Because of their abundance, and because they make up an overwhelming majority of all timberlands in some regions, these lower productivity timberlands are important regionally and nationally. They account for 77% of timberlands in the North, 58% in the South, 81% in the Rocky Mountains, and 52% in the Pacific Coast.

Trends in Timberland Area

Changes in timberland areas can be difficult to track. Some areas have just been inventoried for the first time. In other areas, new and more precise techniques of measuring productivity have resulted in forest land being excluded or included in the timberland base for the first time. And changes in definitions and procedures make comparisons between old and new inventories difficult. So, not all apparent change is real change. Given that caution, a look at the change in the reported timberland base since 1977 is in order.

For the entire United States, timberland area has remained fairly stable over the last decade, with an apparent loss of 8 million acres or 1.6%. Net gains were reported in the North (0.8%) and in the Rocky Mountains (1.6%). On the Pacific Coast, timberland area decreased 7 million acres or 9% from 1977 to 1987 (fig. 23). Most of the decrease was in Alaska, which experienced major shifts in timberland ownership and status; almost 4 million acres of timberland were withdrawn and placed in reserved status as parks and wilderness. Oregon and Washington combined had an apparent loss of 3.2 million acres; much of this loss was due to national forest timberland withdrawals to wilderness status. But some of the apparent timberland loss in these two states was due to land reclassified from timberland to other forest as a result of reevaluation of site productivity. For example, estimates of nonfederal timberlands in eastern Washington were reduced 950,000 acres from earlier estimates, but 87% of the apparent change was due to reclassification of 830,000 acres of timberland to other forest. These "apparent" changes, mingled with real accretions and losses, often make determination of real change difficult. The South has apparently lost 3 million acres or 1.5% of its timberland area in the last decade. Although clearing of bottomland forests for agriculture has slowed in recent years, losses of forest land to urban and other development pressures have increased. Some of the most recent state inventories have shown a slight increase in forest land area.

TIMBER VOLUME, GROWTH AND REMOVALS

The Nation's timberlands support a variety of uses, as do its other forest lands. The primary issue of concern in this report, however, is the volume of timber available now or prospectively for manufacture of wood products. The volume of timber now standing on these timberlands, including the growth that will accrue, constitutes the wood raw material that will provide wood for our forest industries and wood and paper products for our population in the decades to come.

Timber Volume

The Nation's timberlands contain trees of a large variety of species, as was discussed earlier in this chapter. In addition there is variability as to the condition of the trees, which has considerable bearing on their value for use in wood products. It is estimated that the Nation's timberlands contain 831 billion cubic feet of timber, of which 91% is in growing stock—live, sound trees suited for roundwood products (table 38). About 7% of all timber volume is in live cull trees that because of form or rot are not suited for the production of all roundwood products. Almost 2% of the volume of all timber is in dead trees that are sound enough to have value for some product uses. Softwood species have a higher proportion (95%) of all timber volume in growing stock; hardwood volume is 86% growing stock. The remainder of this discussion on timber volume will focus on growing stock.

Softwood Timber Volume

The Nation's softwood timber volume totals 451 billion cubic feet or 60% of all growing stock (table 39). Softwood growing stock is concentrated in the West; the Pacific Coast alone accounts for 44% of all softwood growing stock, despite it's relatively small timberland base. The West contains all of the United States' remaining forests of old timber; these stands have high per-acre

Table 38.—Volume of timber on timberland in the United States, by species group and class of timber, 1987.

Class of timber	Species group		
	All species	Softwoods	Hardwoods
		Million cubic feet	
Growing stock trees	755,935	450,881	305,054
Live cull trees	60,025	13,018	47,007
Sound dead trees	15,354	12,372	2,982
Total, all classes	831,314	476,271	355,043

Table 39.—Volume of growing stock in the United States, by species group and section, 1987.

Section	Species group		
	All species	Softwoods	Hardwoods
		Million cubic feet	
North	187,040	47,400	139,640
South	238,034	103,798	134,236
Rocky Mountains	107,979	100,298	7,681
Pacific Coast	222,882	199,385	23,497
United States	755,935	450,881	305,054

volumes, and many of the younger mature forests on the Pacific Coast have higher per-acre volumes due to the high productivity of much of the timberland. Most of the remainder of softwood timber is evenly distributed between the South and the Rocky Mountains (fig. 24).

Douglas-fir is the most abundant softwood species; it totals 91 billion cubic feet or 20% of all softwood timber volume in the United States. Sixty-one percent of all Douglas-fir volume is in Oregon and Washington (Waddell et al. 1989: table 15). Other important western softwood species in order of volume abundance are: true firs (41 billion cubic feet); western hemlock (38 billion cubic feet); ponderosa pine (33 billion cubic feet); lodgepole pine (27 billion cubic feet); spruce (21 billion cubic feet). The location of volume concentration of these species follows closely the distribution of the namesake forest types discussed earlier.

Eastern softwood species are primarily in the South, an area which in recent years has become a focal area for new investments by forest industries. This change in balance in terms of timber harvest and industrial development between the Pacific Coast and the South has resulted, in part, from the declining supplies of large old timber on private lands on the Pacific Coast, and increases in inventories of softwoods in the South in recent decades. Eastern softwoods account for one-third of the Nation's softwood timber; Southern pines alone account for 23%.

Loblolly and shortleaf pines total 69 billion cubic feet or 66% of all softwood timber volume in the South and 46% of all softwood volume in the East (Waddell et al. 1989: table 11). Other important Eastern softwoods include: longleaf and slash pines (17 billion cubic feet); red and white pines, located in the Northeast and North Central regions (14 billion cubic feet); spruce and balsam fir, located in the North (18 billion cubic feet); other yellow pines (11 billion cubic feet).

Hardwood Timber Volume

Hardwoods account for 40% of all growing stock volume in the United States. Fully 90% of all hardwood timber volume is in the eastern United States, almost evenly distributed between the North and the South. Most of the remaining 10% is on the Pacific Coast (table 39).

The hardwoods of the East are numerous, and their unique characteristics warrant tracking many of them as separately identifiable species (Waddell et al. 1989: table 12). The oaks total 98 billion cubic feet. The select species, which include select white and red oaks, hard maple, yellow birch, sweet gum, yellow-poplar, ash, black walnut, and black cherry, total 114 billion cubic feet or 41% of all hardwood growing stock in the eastern United States. Although there is an apparent abundance of select species, much of the volume is in relatively small trees of limited use for many products where quality is important (Waddell et al. 1989: table 22). In the East, 42% of all hardwood timber volume is in trees less than 11 inches in diameter.

Western hardwoods are of little importance when compared to the vast softwood resources in the West, or the hardwood resources in the East. But locally they are important, and their use is growing as softwoods become more limited in supply. Red alder, with an inventory of almost 8 billion cubic feet, has had a substantial increase in use in recent years. It is located almost entirely in the Douglas-fir subregion of Oregon and Washington. The aspens in Colorado and other states in the Rocky Mountains are also locally important.

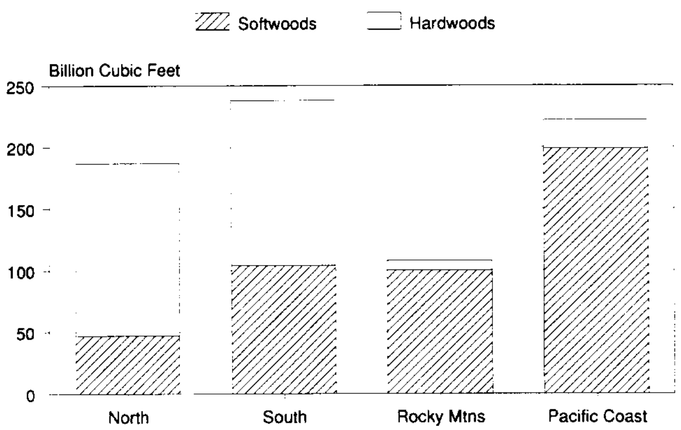


Figure 24.—Volume of growing stock in the United States, by section, 1987.

Ownership of Timber Volume

The pattern of ownership of timberland area is not a good indication of distribution of timber volumes among the same owner groups. Because of many factors, among them history of use, land productivity, and degree of management, the timber volumes are distributed unevenly among owners. National forests, which account for only 18% of the Nation's timberland, have 28% of all timber volume, and 41% of all softwood timber volume (table 40). The national forests still have considerable area in old stands with high per-acre volumes. The national forests have less hardwood volume than the other owner groups (fig. 25).

Other public owners—states, federal agencies other than the Forest Service, counties and municipalities—account for about 12% of all timber, about two-thirds

Table 40.—Volume of growing stock in the United States, by species group and ownership, 1987.

Class of timber	Species group: All species	Softwoods	Hardwoods
	Million cubic feet		
National forest	211,099	186,388	24,711
Other public	88,319	56,839	31,480
Forest industry	107,275	72,340	34,935
Other private	349,242	135,314	213,928
All ownerships	755,935	450,881	305,054

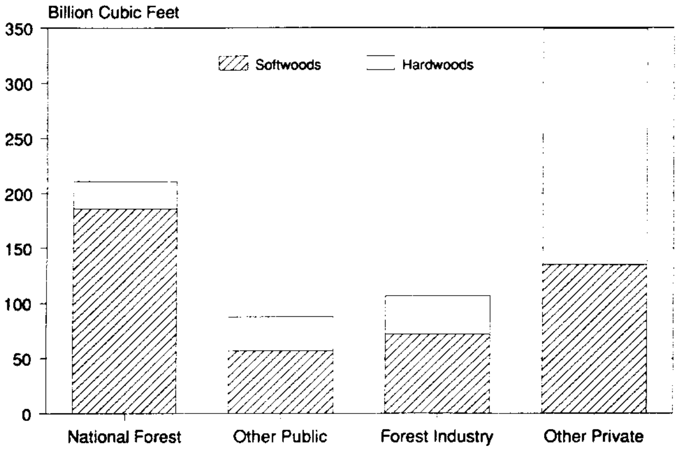


Figure 25.—Volume of growing stock in the United States, by species group and ownership, 1987.

of which is softwoods. The hardwood volume in this owner group is concentrated in the North; the softwood volume is mostly in the West, the largest share in Oregon and Washington.

Forest industries account for about 15% of all timber volume in the United States, and 16% of all softwood volume. This group of timberland owners accounts for a small part of total timberland and timber volume in most regions, but is locally important in many states and areas. Industry timber is important beyond its relative abundance because industry owners hold and manage timber for harvest. Inventory turnover—the rate of harvest and replacement of timber inventories—is higher on forest industry land than on other ownerships.

Farmer and other private timberlands account for 46% of all growing stock in the United States, a proportion less than the timberland area share of this owner group might indicate, but nevertheless a large and important resource. This owner group controls 30% of all softwood timber, and 70% of all hardwood timber. Both softwood and hardwood timber volume in this owner group is concentrated in the eastern United States, softwoods in the Northeast, Southeast, and South Central regions; hardwoods are abundant in this ownership throughout the East.

Trends in Timber Volume

Earlier national assessments reported 5% net gains in timber between 1962 and 1970, and between 1970 and 1977, despite losses of timberland area in some regions (USDA FS 1982). For the period 1977–1987, we have found an overall increase of about 4% (31 billion cubic feet) nationally (table 41). This net trend masks some offsetting trends for individual regions, and for some species of timber. Timber volume on the Pacific Coast decreased 9% during the 1977–1987 period; softwood volume, which was responsible for the downward trend in that section of the country, decreased over 12%, and was responsible for the slight decline in softwood timber volume nationally. Softwood timber volume was up 5 to 8% in all other sections of the country.

Hardwood timber volume increased significantly in all sections of the country, continuing a trend that dates to the early 1950s and before. The North and South accounted for most of the hardwood volume increase, but the rate of increase was greatest in the Rocky Mountains and Pacific Coast, at 25%.

Because changes in timberland area account for part of the change in total timber volume, scrutiny of volume change on a per-acre basis sometimes provides different insights about the rates and locations of changes in volumes. For instance, the South, which had a 10% increase in total volume in the last decade, experienced a 12% gain in volume on a per-acre basis; while in the North, timber volume increased 13% per acre compared to a 15% total volume increase. The per-acre volumes remove area changes from the comparisons, and provide a better tool for looking at dynamics of the forests, in terms of growth, removals, and growing stock volume. Figure 26 also provides ready comparisons of the average concentrations of timber volume in the different sections of the country.

Although average timber volume per acre has declined on the Pacific Coast, this section's timberland still has almost three times the volume per acre of the timberlands of the South and North. As the old timber in the Pacific Coast and Rocky Mountain sections is harvested, the per-acre volumes will continue to decrease. But most of the

Table 41.—Change in growing stock volume in the United States, by species group and section, 1977–1987.

Section	All species		Softwoods		Hardwoods	
	Million cubic feet	*Percent*	*Million cubic feet*	*Percent*	*Million cubic feet*	*Percent*
North	24,032	14.7	3,550	8.1	20,482	17.2
South	22,650	10.5	4,902	5.0	17,748	15.2
Rocky Mountains	6,730	6.6	5,187	5.5	1,543	25.1
Pacific Coast	−22,544	−9.2	−27,406	−12.1	4,862	26.1
United States	30,868	4.3	−13,767	− 3.0	44,635	17.1

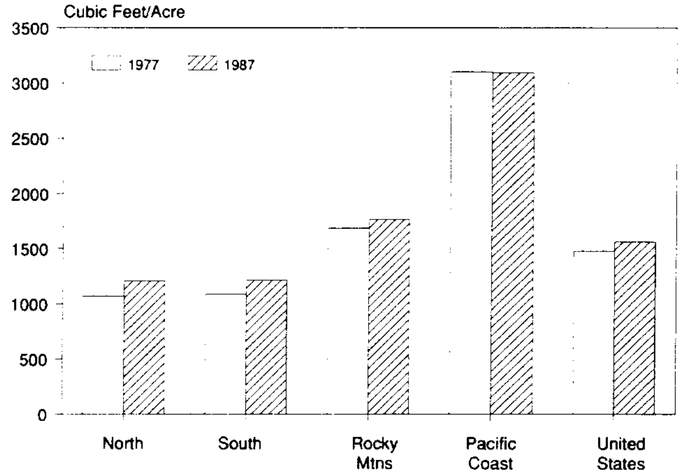


Figure 26.—Volume of growing stock per acre in the United States, by section, 1977 and 1987.

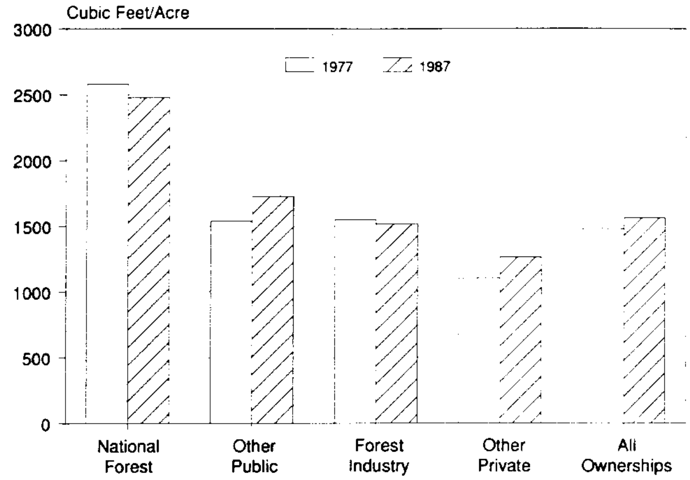


Figure 27.—Volume of growing stock per acre in the United States, by ownership, 1977 and 1987.

old timber is gone on all but national forest lands in the Pacific Coast; in this section of the country, longer rotation ages for young timber and relatively high productivity of timberlands result in high per-acre volumes in restocked young forests. Industry timberlands in the Northwest Region, though they have little remaining old timber, have about three times the volume per acre of industry timberlands in the Southeastern region. The increase in per-acre volume in the Rocky Mountains is of interest because of the commonly held perception that this section, whose forests are mostly publicly owned, has old forests whose growth has stagnated. Although timber growth in this section of the United States is lower than in some other sections of the country, it far exceeds the demands made on the timber resource by timber harvest. As a result, growing stock volumes have increased in this section of the country.

Changes in Timber Volume by Ownership

Timber volume increased in the last 10 years for all ownerships except national forests, which had an 8% decrease in volume (table 42). Growing stock volume increased 4% on other public lands, and 14% on farmer and other private timberlands. On industry lands, total timber volume increased 1%. The totals for all species mask declines in softwood timber volume on other public and forest industry lands. The decline in softwood timber volume on industrial lands during the decade was a modest 2.4%; on other public lands it was 3.5%, and on national forests, 10%. On farmer and other private lands, softwood timber volume increased about 9%. Hardwood timber volume increased substantially on all ownerships over the last decade.

Per-acre analysis of volume change by owner over the last decade does indicate some differences in magnitudes of change, but not direction (fig. 27). On national forests, volume per acre decreased about 4%, half of the decline rate for total timber in this ownership. The analysis of volume change on a per-acre basis removes from the analysis the impact of timberland loss to wilderness withdrawals and other uses, and provides a clearer picture of the impacts of harvest, mortality, and growth dynamics. On other public timberlands, the percentage volume increase on a per-acre basis (12%) over the last decade is over three times the percentage increase in total volume. On a per-acre basis, forest industry shows a slight loss (1%) versus a slight increase (1%) in total volume, because the impact of volume increase through timberland purchase is nullified when using the per-acre approach. For farmer and other private ownerships, both

Table 42.—Change in growing stock volume in the United States, by species group and ownership, 1977–1987.

Ownership	All species		Softwoods		Hardwoods	
	Million cubic feet	*Percent*	*Million cubic feet*	*Percent*	*Million cubic feet*	*Percent*
National forest	-17,922	-7.8	-21,589	-10.4	3,667	17.4
Other public	3,115	3.7	- 2,081	- 3.5	5,196	19.8
Forest industry	1,358	1.3	- 1,752	- 2.4	3,110	9.8
Other private	44,317	14.5	11,655	9.4	32,662	18.0
All ownerships	30,868	4.3	-13,767	- 3.0	44,635	17.1

total volume and per-acre volume increased about 15% over the last decade.

Elements of Change in Timber Volume

Timber inventories are dynamic. The net change in timber volume is affected by a number of factors, some within owners' or managers' control, and some beyond their control. In the previous section, the impact of area change on inventory was alluded to in comparing the difference in rates of change achieved when looking at per-acre values. When timberland area is shifted from one owner to another, converted to another use, or withdrawn from timber production (for example, park or wilderness use), volume is removed from the inventory of one owner group, and may or may not be added to another. The impacts on timber volume change are not precisely known, but if the average volume on the lost acres is representative of average volume for the entire ownership class, the volume loss/gain due to timberland transfer or withdrawal is proportional to the timberland area lost. While such inventory losses can be estimated, they tell us little about the dynamics of forests and their uses as timberland. The focus here will be on the elements of dynamic change within forests—mortality, growth, and harvest.

Timber Volume Lost to Mortality

Timber mortality is commonly defined as the net volume of timber dying annually (or for some other period) due to insects, disease, suppression, fire, and windthrow. Mortality is a part of every living forest. Usually, losses due to insects, disease, and suppression occur at a low and predictable rate. Little of this type of timber loss is captured for harvest because the dead trees are widely scattered, not providing economic concentrations of timber volume needed to support profitable harvest operations.

Timber volume loss to mortality can also occur in huge concentrations in localized areas, through epidemic insect infestations, wildfire and windstorms. Timber killed, but not destroyed, in such catastrophic events is often salvaged and utilized for the production of timber products.

Loss of growing stock to mortality totaled 4.5 billion cubic feet in 1986 (table 43), about 0.6% of the growing stock volume in the United States. The distribution of mortality is consistent and very predictable, absent periodic catastrophes. For both softwoods and hardwoods, and for each owner group, the mortality rate (volume loss to mortality as a percent of growing stock) varied between 0.5 and 0.7%. The highest mortality rate in 1986 was for farmer and other private softwoods; the lowest was for other public softwoods. But the differences, even at the extremes are of little practical significance. The largest losses to mortality occur where the largest concentrations of timber are found. But even in areas of high timber volumes, the concentration of mortality is so small at the acre level, barring catastrophic loss, that trying to capture mortality for harvest is not a realistic concept. For the United States as a whole, mortality averages only 9 cubic feet per acre annually. On the Pacific Coast, mortality averages about 15 cubic feet per acre annually; in the eastern regions, it ranges from 7 to 11 cubic feet per acre.

Table 43.—Mortality of growing stock in the United States, by species group and ownership, 1986.

Ownership	Species group: All species	Softwoods	Hardwoods
	Million cubic feet		
National forest	1,053	912	141
Other public	502	294	208
Forest industry	635	408	227
Other private	2,271	982	1,289
All ownerships	4,461	2,596	1,865

Table 44.—Net annual growth of growing stock in the United States, by species group and ownership, 1986.

Ownership	Species group: All species	Softwoods	Hardwoods
	Million cubic feet		
National forest	3,433	2,810	623
Other public	2,355	1,381	974
Forest industry	4,371	3,216	1,155
Other private	12,367	5,463	6,904
All ownerships	22,526	12,870	9,656

Timber Growth

Net annual growth is a commonly used measure of productivity and performance of timber resources. Net annual growth is annual growth of timber volume, less the volume lost through mortality and increase in cull volume. In other words, it is the net effect of natural gains and losses to timber volume. Although net growth is sometimes used as an indication of timber available for harvest, this simple concept of harvest availability is often misleading and is best not used.

Net annual timber growth.—Net annual timber growth (net growth) totaled 22.5 billion cubic feet in 1986 (table 44). Fifty-five percent of all timber growth and 72% of all hardwood growth was on farmer and other private timberlands. Forest industry accounted for 19% of all timber growth, and 25% of all softwood growth, percentages much larger than their share of timberland and timber volume.

On a per-acre basis, net growth on forest industry timberlands averaged 62 cubic feet annually, far in excess of any other ownership (fig. 28). This high level of growth reflects the high productivity of timberlands in this ownergroup, as well as the age, stocking levels, and levels of management of the timber stands thereon. National forests have lands of poorer productivity and many old stands with relatively slow growth. As a consequence they have the lowest per-acre growth of any owner group (40 cubic feet).

Timber growth is distributed among all the sections and regions of the country. The South accounts for about 46% of all timber growth, softwood growth, and hardwood growth (table 45). The South and North combined account for most (91%) of total hardwood growth. The Rocky Mountains and Pacific Coast combined have 45% of all softwood growth.

On a per-acre basis, the Pacific Coast has the highest rate of growth (62 cubic feet) of all sections of the country (fig. 29). The Rocky Mountains and North have the lowest per-acre growth rates, considerably lower than those for the Pacific Coast and South.

Trends in timber growth.—Total timber growth increased about 3% between 1976 and 1986. These trends

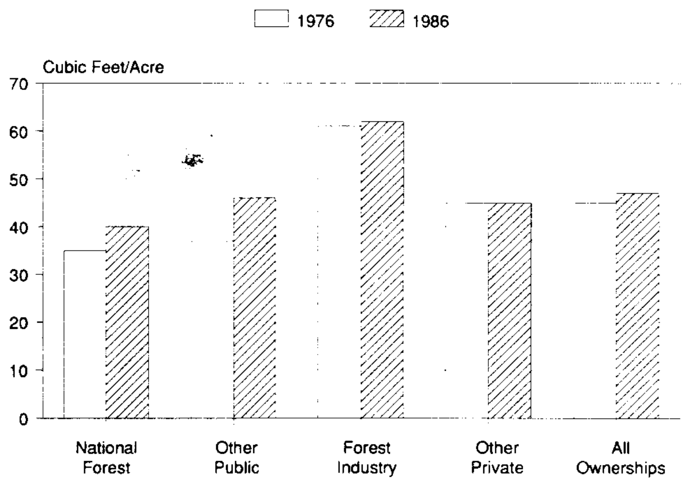


Figure 28.—Net annual growth of growing stock per acre in the United States, by ownership, 1976 and 1986.

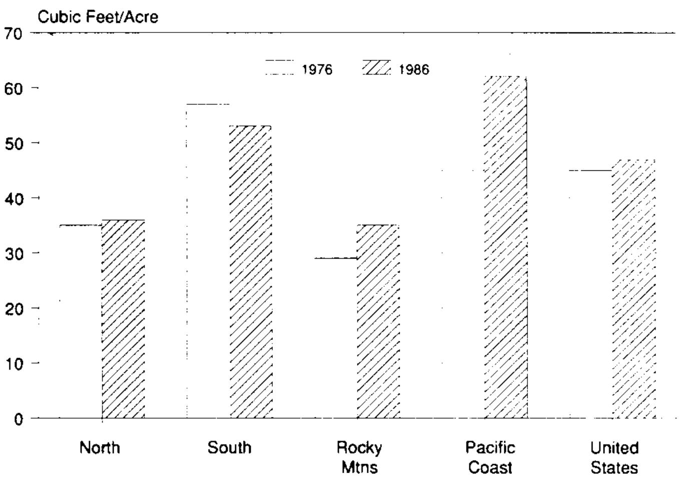


Figure 29.—Net annual growth of growing stock per acre in the United States, by section, 1976 and 1986.

Table 45.—Net annual growth and removals of growing stock in the United States, by species group and section, 1986.

Item	Species group		
	All species	Softwoods	Hardwoods
	Million cubic feet		
North			
Net growth	5,512	1,288	4,224
Removals	2,708	726	1,983
Ratio of growth to removals	2.04	1.77	2.13
South			
Net growth	10,429	5,849	4,580
Removals	8,698	5,741	2,958
Ratio of growth to removals	1.20	1.02	1.55
Rocky Mountains			
Net growth	2,127	1,957	170
Removals	871	843	28
Ratio of growth to removals	2.44	2.32	6.07
Pacific Coast			
Net growth	4,458	3,776	682
Removals	4,173	4,058	115
Ratio of growth to removals	1.07	.93	5.93
United States			
Net growth	22,526	12,870	9,656
Removals	16,451	11,367	5,083
Ratio of growth to removals	1.37	1.13	1.90

are best examined by looking at per-acre growth to minimize the effects of change in area estimates. Net growth per acre increased 38% in the Pacific Coast, due largely to the emergence of young stands of timber following the extensive harvest of old timber on nonfederal lands during the post World War II era (fig. 29). Per-acre growth in the South remains relatively high, but a negative trend is evident, in keeping with studies that have identified declining growth rates in the South in recent years (Sheffield et al. 1985). Per-acre growth has been stable in the North. In the Rocky Mountains, growth per acre has increased 21%; the per-acre growth in the Rocky Mountains is now about the same as per-acre growth in the North.

Growth trends by ownership.—On national forests, per-acre growth has increased 14% in the last decade; on other public lands, growth per acre increased about 26% (fig. 28). Per-acre growth on forest industry land increased about 2%. A slight decrease in per-acre growth occurred on farmer and other private timberlands.

The decreases in growth on farmer and other private timberlands in the South mark a change in direction from recent trends of increasing growth. The reasons for change in long-term growth trends are currently the subject of much study and considerable speculation. Causal factors for the declines in growth have not yet been conclusively determined.

Removals of Timber Volume

Removals from timber inventories are losses that occur by other than natural causes (mortality). Removals, mortality, and land dedication to nonforest uses are the negative elements of change that, with growth and reforestation of abandoned agricultural land as positive elements, determine the direction or trend in timber volume over time. Timber removals from growing-stock volume include: (1) harvest of roundwood products; (2) logging residues; and (3) other removals, such as precommercial thinning, and land clearing with resultant destruction of timber. Not included in the removals discussed herein are the timber inventories on timberlands withdrawn intact for parks and wilderness. We have focused here on timber removals from growing-stock inventory that are or can be potentially used for wood products.

Timber removals from growing-stock inventory in 1986 totaled 16.5 billion cubic feet (table 45). Almost 53% of all timber removals came from the forests of the South, which continued to increase its share of timber harvest in the United States. Twenty-five percent of all removals came from the Pacific Coast forests, 16% came from the North, and only 5% from forests in the Rocky Mountains.

Softwoods accounted for 69% of all growing-stock removals in 1986. The forests of the South accounted for 50% of all softwood removals, the Pacific Coast 36%, the Rocky Mountains 7%, and the North 6%. Hardwood removals in 1986 were centered in the North and South, which together accounted for 97% of the United States total. The South accounted for 58% of all hardwood removals from growing stock in 1986.

Timber removals were concentrated on private ownerships in 1986. Farmer and other private owners had 50% of all timber removals, industrial forests accounted for 30% (table 46). The national forests, although a major factor in the West, accounted for only 13% of total growing-stock removals in 1986. Other public, with 7% of total removals, was the least important source of removals nationally, but was important in some states and local areas, including the Douglas-fir subregion in the Northwest.

The ownership distribution of removals by species group was somewhat different than the all-species distribution due to the differences in species volume distribution between the owner groups. Forest industry accounted for 37% of all softwood removals, farmer and other private 38%, national forests 18%, and other public 7%. Hardwood removals came primarily from farmer and other private forests (76%).

Changes in timber removals.—Comparison of removals in 1986 with those in 1976 indicates that recent (1986) removals are 16% higher than those in 1976 (table 47). These data are for two points in time and, in themselves, do not establish a trend.

Hardwood removals in 1986 were higher than in 1976 by 21%; softwood removals increased 14%. Removals from national forests were 5% higher in the recent year. Removals from other public lands changed little in 1986,

Table 46.—Net annual growth and removals of growing stock in the United States, by species group and ownership, 1986.

Item	Species group		
	All species	Softwoods	Hardwoods
	Million cubic feet		
National forest			
Net growth	3,433	2,810	623
Removals	2,172	2,010	162
Ratio of growth to removals	1.58	1.40	3.85
Other public			
Net growth	2,355	1,381	974
Removals	1,083	862	221
Ratio of growth to removals	2.17	1.60	4.41
Forest industry			
Net growth	4,371	3,216	1,155
Removals	5,007	4,195	812
Ratio of growth to removals	87	.77	1.42
Other private			
Net growth	12,366	5,462	6,904
Removals	8,189	4,300	3,889
Ratio of growth to removals	1.51	1.27	1.78
All ownerships			
Net growth	22,526	12,870	9,656
Removals	16,451	11,367	5,083
Ratio of growth to removals	1.37	1.13	1.90

Table 47.—Removals of growing stock in the United States, by ownership and species group, 1976 and 1986.

Ownership and Species group	1976	1986	Percentage Change
	Thousand cubic feet		*Percent*
National forest			
Softwoods	1,990	2,061	3.6
Hardwoods	128	162	26.6
Total	2,118	2,223	5.0
Other public			
Softwoods	850	858	0.9
Hardwoods	226	220	-2.7
Total	1,076	1,078	0.2
Forest industry			
Softwoods	3,616	4,214	16.5
Hardwoods	599	812	35.6
Total	4,215	5,026	19.2
Other private			
Softwoods	3,543	4,234	19.5
Hardwoods	3,242	3,889	20.0
Total	6,785	8,123	19.7
All owners			
Softwoods	9,999	11,367	13.7
Hardwoods	4,195	5,083	21.2
Total	14,194	16,450	15.9

compared to 1976. On forest industry lands, removals were much higher in the recent year, with a 36% increase for hardwoods and a 16% increase for softwoods. On farmer and other private lands, both hardwood and softwood removals were about 20% higher in 1986 than in 1976.

In the North, removals increased 8%; all of the increase occurred in the North Central region (table 48, Waddell et al. 1989: table 29). In the South, removals increased 30% with substantial increases in both the South Central and Southeast regions. In the Rocky Mountains and the Pacific Coast, removals were about the same for both years.

Table 48.—Removals of growing stock in the United States, by section and species group, 1976 and 1986.

Section and Species group	1976	1986	Percentage Change
	Million cubic feet		Percent
North			
Softwoods	692	726	4.9
Hardwoods	1,803	1,983	10.0
Total	2,495	2,708	8.5
South			
Softwoods	4,436	5,741	29.4
Hardwoods	2,242	2,958	31.9
Total	6,678	8,699	30.3
Rocky Mountains			
Softwoods	843	843	0.0
Hardwoods	24	28	16.7
Total	867	871	0.5
Pacific Coast			
Softwoods	4,028	4,058	0.7
Hardwoods	126	115	-8.7
Total	4,154	4,173	0.5
United States			
Softwoods	9,999	11,367	13.7
Hardwoods	4,195	5,083	21.2
Total	14,194	16,451	15.9

Timber products output.—Timber products output from growing stock accounts for most of the timber removed from timberlands (table 49). In 1986, 88% of all softwood removals and 76% of all hardwood removals were in the form of roundwood used as raw material for the manufacture of wood products.

Roundwood products accounted for 88 to 90% of total softwood removals in all sections of the country. Hardwood roundwood products accounted for 78% and 73%, respectively, of the total hardwood removals in the North and South.

Logging residues.—Logging residues are materials removed from growing stock in the process of timber harvest, which are left unutilized at the harvest site. Theoretically, they represent raw material that could be used in the manufacture of wood products. But the size, species, concentrations, and/or condition of the material has rendered it unsuited for manufacture of products at that time, or simply not economic to transport to the processing facilities. Thus logging residues are not unjustified waste, but they may be a source of raw material in the future as products, the price of raw materials, or the economics of manufacturing change.

Logging residues accounted for 9% of all softwood growing-stock removals and 11% of all hardwood removals in 1986 (table 49). In the Rocky Mountains and Pacific Coast, softwood logging residues were 11 and 12%, respectively, of total removals; but in the South and North, softwood logging residues were only 6 and 4%, respectively, of total removals. The higher proportion of removals left as logging residue in the West is due, in part, to breakage and other factors associated with logging of old timber, and due to operation in steep, remote terrain.

Hardwood logging residues as a percent of total removals varied from 7% in the Pacific Coast to 18% in the Rocky Mountains. In the eastern part of the United

Table 49.—Roundwood products, logging residues, and other removals from growing stock timberland in the United States, by species group and section, 1986.

	Species group											
	All species				Softwoods				Hardwoods			
Section	Total	Roundwood products	Logging residues	Other removals	Total	Roundwood products	Logging residues	Other removals	Total	Roundwood products	Logging residues	Other removals
	Million cubic feet											
North	2,708	2,202	201	305	726	654	31	40	1,983	1,548	171	264
South	8,698	7,260	764	674	5,741	5,091	364	286	2,958	2,169	400	389
Rocky Mountains	871	771	96	4	843	752	91	—	28	20	5	3
Pacific Coast	4,173	3,651	520	2	4,058	3,545	512	1	115	106	8	1
United States	16,451	13,884	1,582	984	11,367	10,042	998	327	5,083	3,843	584	657

States, where hardwood removals are concentrated, hardwood logging residues totaled 571 million cubic feet, and accounted for 9% of hardwood removals in the North, 14% in the South.

Although logging residues cannot be considered an immediate raw material resource, the economics and technology of harvest and manufacture and the nature of raw material used for wood products do change with the passage of time. In the past, the result of such change has been an increase in degree of utilization and a decreasing proportion of growing stock left as logging residue. Since 1976, the proportion of softwoods left as logging residues has remained at 8%; but hardwood logging residues have decreased from 14% to 11% of hardwood growing-stock removals. However slowly, decreasing trends in logging residues will likely continue. The expansion of available raw material for manufacture will result from these trends, not from utilization of what was left on the ground in 1986.

Other removals.—Other removals consist largely of growing stock cut and burned or otherwise destroyed in the process of conversion of forest land to nonforest uses. A secondary source of other removals is growing stock killed and not utilized in forestry cultural operations such as precommercial thinning. These removals, like logging residues, are not a potential immediate source of raw materials; but changing economics may some day make more of this material available for product manufacture. In 1986, 6% of all growing-stock removals fell into the category of other removals (table 49). Only 3% of softwood removals were in this category, but fully 13% of hardwood removals were so classified. The hardwood growing stock lost to other removals was in the South and the North; the losses were due largely to continued clearing of bottomland hardwood stands in the South for farmland; in the North, the hardwood forests were removed to yield land to a number of nonforest uses.

Most of the softwood growing stock classified as other removals in 1986 was in the South, and likely was scattered softwoods in predominantly hardwood stands that were converted to nonforest uses.

When timberland is converted to nonforest use, some wood raw material is usually destroyed in the process. But wood that is valuable for product manufacture, if in economic concentrations, is usually utilized and is included in the roundwood products category of removals.

Products from growing stock and other timber.—Roundwood timber products come largely from growing stock. Most attention is focused on roundwood products from growing stock because of the overwhelming importance of that source, and because harvest from growing stock has an effect on growing-stock inventories which are tracked and studied because of their commercial importance. But roundwood products also come from such nongrowing-stock sources of wood raw material as dead trees, live cull trees that are largely rotten or are rough in form, very small trees, trees of seldom used species, and trees from nonforest land (fencerows, etc.).

In 1986, roundwood products from all domestic sources in the United States totaled 17.6 billion cubic feet, of which growing stock accounted for 79%, other sources 21% (table 50). Only 11% of all softwood roundwood products came from nongrowing stock. But the situation was different for hardwoods; 38% of all hardwood roundwood products came from nongrowing-stock sources.

The major reason for the high proportion of nongrowing stock in total hardwood harvest is fuelwood. Hardwoods accounted for 82% of all roundwood harvested for fuelwood in 1986. And nongrowing stock accounted for 77% of all hardwood used for fuelwood. For fuelwood use, species, tree form and size are of minor importance to the value of wood. Location, availability, and low cost are primary concerns; as a consequence, much fuelwood comes from species of lesser value for other roundwood products, and small trees or trees that are too poorly formed for timber and other products. Nongrowing stock accounted for a minor part of the wood supply for all other products. The fuelwood harvest was concentrated in the eastern United States. Sawlogs accounted for 40% of total roundwood harvest in 1986. This roundwood product, used in the production of lumber, accounted for 48% of all softwood harvested, but only 27% of all hardwood. Sawlog harvest was concentrated in the South Central and Southeast

Table 50.—Volume of roundwood harvested in the United States, by source of material, species group, and product, 1986.

Product	All sources			Growing stock			Other sources		
	Total	Softwoods	Hardwoods	Total	Softwoods	Hardwoods	Total	Softwoods	Hardwoods
	Million cubic feet								
Sawlogs	7,064	5,395	1,668	6,722	5,175	1,546	342	220	122
Pulpwood	4,788	3,103	1,685	3,894	2,481	1,413	894	622	272
Veneer logs	1,540	1,433	107	1,439	1,337	102	101	96	5
Fuelwood	3,114	545	2,568	798	206	592	2,316	339	1,977
Other products	1,087	868	219	1,031	842	189	56	26	30
All products	17,593	11,345	6,248	13,884	10,042	3,843	3,708	1,303	2,405

regions, and in the Pacific Coast; these regions combined accounted for 77% of the timber harvested for sawlogs (Waddell et al. 1989: table 30).

Pulpwood roundwood accounted for 27% of total timber harvest in the United States in 1986. Almost two-thirds of the pulpwood harvested was softwoods. Eighty-nine percent of all pulpwood roundwood was harvested in the Eastern United States, the South alone accounting for 69%. Although the Pacific Coast has a substantial pulp industry, most of the wood raw material is chips produced as byproduct of the manufacture of lumber.

Other products include roundwood harvested for cooperage, mine timbers, poles, pilings, posts, shakes, shingles, and logs for export. In 1986, timber harvested for these products totaled almost 1.1 billion cubic feet or 6% of all roundwood harvests. Eighty percent of the harvest for these products was softwoods. Sixty percent of the harvest for other products was concentrated on the Pacific Coast, the majority of which was logs for export. Most of the remainder of harvest for other products was in the North (21%) and the South (15%).

Timber Growth/Removal Balances

Comparisons of net growth and removals provide a spot check of the balance between the two, and by inference, an indication of what will happen to the inventory for the year of comparison. But while annual growth for any one year gives a good indication of what growth might be expected for the next few years, the removals for any given year, such as 1986, can be substantially different than the year preceding or the year following, due to the overwhelming impact of market demand on levels of timber harvest, which is the major component of removals. So, although these comparisons are interesting, they should not be used to draw inferences about long-term growth/removals balance and their effect on trends in timber inventories.

Growth/removals balance can be expressed as a ratio of growth to removals. A ratio exceeding 1 means that growth exceeds removals for the year in question; a ratio of less than 1 indicates removals in excess of growth and, for that year, a resulting decrease in inventory volume.

The growth/removals balance for the United States is positive for all species (1.37), for softwoods (1.13), and for hardwoods(1.90) (table 45). These ratios are lower than comparable ratios for 1976. The ratios in the North are very high, indicating continued substantial increases in growing-stock volume if harvests and removals remain at 1986 levels. The softwood ratio in the South is approaching 1—a stable inventory situation. The growth/removals ratio in the Rocky Mountains exceeds 2, and is higher than the 1976 ratio, due largely to increased growth. The ratio on the Pacific Coast is 1.07; for softwoods it is .93. For this section of the country, the ratio has improved by about .2 since 1976, due to growth increases in excess of increases in removals. These ratios do indicate continued decreases in softwood inventory on the Pacific Coast.

The current ratios by ownership are positive for all owner groups but forest industry. The 1986 growth/removals ratio for national forests is 1.6; for other public forest it is 2.2 for all species and 1.6 for softwoods; farmer and other private lands have a ratio of 1.5 for all species, 1.3 for softwoods, and 1.8 for hardwoods (table 46). For forest industry forests, the 1986 ratio of growth to harvest for all species is .87; for softwoods it is .77, due to high timber harvest levels in 1986. The hardwood growth/removals ratio for this owner group is 1.4.

Some words of caution are in order with reference to these ratios. They indicate balance only for the year or years cited, because the levels of removals are not stable from year to year, but can change suddenly. And the ratios here are developed for very large aggregates of forested areas, timber species, and owners. A high ratio for hardwoods as a whole means nothing with reference to individual, highly prized species such as black walnut. Any individual species, or a state or local area, may have a far different growth/harvest balance than the aggregate in which it occurs.

CHAPTER 4. ECONOMIC IMPORTANCE OF THE TIMBER PROCESSING INDUSTRIES

THE IMPORTANCE OF THE FOREST INDUSTRIES

The value of the timber produced from our Nation's forests made timber the number one agricultural crop in this country in 1986. The lumber and other solid-wood products industry ranks in the top three manufacturing industries in most regions in the country, while the paper and allied products industry ranks in the top five in one subregion. Many areas rely upon harvesting and processing of forest products for major support of local and regional economies. Many people depend upon these industries to provide both employment and income and to contribute to the economic diversity of the communities in which they live.

Timber consumption in the United States is determined by both the demand for wood products such as houses, furniture, and paper, and the available timber supplies to manufacture these products. A large and varied forest products industry has evolved within the United States to meet these demands. The primary timber processing industries are the point at which consumer demands for wood products and available timber supplies first meet. These industries provide the initial conversion of the timber resource into the wood products demanded by consumers. The secondary wood processing industries are dependent upon the products of the primary timber processing industries for their raw materials to further process wood products for final consumption. The conversion of standing timber into forest products requires a high level of industrialization and diversity within the forest products industries in the United States.

Over time, the timber processing industries have responded to changes, in both consumer demand and timber supply, by developing new products and processing technologies. These developments help to satisfy existing demands, while creating new demands for wood products. New products and technologies also use existing components more efficiently and create new uses for previously unused components. They also assist in maintaining competitiveness in national and international markets. Improvements in conversion of the forest resource are most apparent in product recovery, where new technologies increase the production of forest products from roundwood. Since our consumption of wood products is ultimately determined by this ability of the timber processing industries to convert roundwood into usable wood products, it is important to understand how these industries operate if we are to ensure that projected levels of consumer demand can be satisfied.

This chapter begins with a discussion of the volume and value of the roundwood products harvested in the United States. These values are then compared with agricultural crops to provide a sense of scale for the forest products industry. The scope of forest industry manufacturing is discussed in the context of regional and national economies. Next, a comparison with all other manufacturing industries is provided. This is followed by a discussion of the relative importance of the timber processing industries, by industry type and region. The chapter ends with a detailed discussion of the primary timber processing industries, nationally and regionally, focusing on employment, wages and salaries, value added by manufacture, value of shipments, production capacity, production costs, recovery factors, and production trends in each industry.

Volume and Value of Roundwood Timber Products

The timber harvested from our Nation's timberlands is initially processed as logs, bolts, and other roundwood products. Most roundwood comes from growing stock sources on timberlands. Removals of dead, rough, rotten, and small trees, stumps, tops, and limbs, as well as trees from fencerows, urban areas, and other nontimberland sources also increase total roundwood supply.

Production of Roundwood Timber Products

In 1986, an estimated 17.6 billion cubic feet of roundwood timber products were harvested in the United States. Of this, over 11.3 billion cubic feet came from softwood species, and 6.3 billion cubic feet came from hardwood species (Waddell et al. 1989: table 30).

The estimated value of this roundwood timber harvest in 1986 was $5.7 billion, with 84% being derived from the harvest of softwood timber and the remaining 16% from hardwood species (McKeever and Jackson 1990: table B-1). These values are based on softwood and hardwood stumpage prices provided by the Regional Offices of the National Forest System of the U.S. Forest Service. When the value added from harvesting the timber and moving it to a local point of delivery, such as a rail siding or concentration yard, is included, the value of the 1986 roundwood output in the United States was approximately $12.6 billion (table 51).

Relative Importance of Roundwood Products

A diversity of timber products used for both industrial and consumer applications is represented in the total roundwood harvest. Better quality trees are processed into lumber, while many of the largest and best logs become veneer logs and are processed into plywood. Together, 8.6 billion cubic feet of sawlogs and veneer logs were harvested in 1986, accounting for 49% of total roundwood production. Softwood harvest for sawlogs constituted 5.4 billion cubic feet (31%), while hardwoods harvested for sawlogs were 1.7 billion cubic feet (9.5%). The volume of softwood roundwood produced

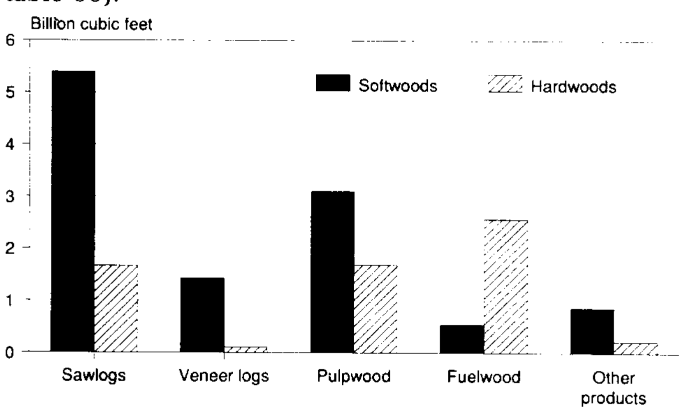
Table 51.—Estimated values at local points of delivery of roundwood timber products[1] and other agricultural crops[2] in the United States, by region and subregion, 1986.

Region and subregion	Value of roundwood timber products	Value of other agricultural crops	Value of roundwood timber products as a percentage of other agricultural crops
	Million dollars		*Percent*
North			
Northeast	867	2,910	30
North Central	760	20,125	4
Total	1,627	23,035	7
South			
Southeast	2,311	5,689	41
South Central	2,799	8,078	35
Total	5,110	13,767	37
Rocky Mountain			
Great Plains	15	7,540	(3)
Rockies	789	4,357	18
Total	804	11,897	7
Pacific Coast			
Pacific Southwest	1,032	7,730	13
Pacific Northwest[4]	3,946	2,517	157
Alaska	104	5	2,080
Total	5,082	10,252	50
United States	12,624	59,445	21

[1]*Includes logs, bolts, or other round sections cut from trees.*
[2]*Includes field crops, fruits and nuts, and vegetables of commercial significance.*
[3]*Less than 0.5%.*
[4]*Data for the Pacific Northwest-West and Pacific Northwest-East subregions are not available.*
Sources: Timber: Waddell et al. 1989: table 30; USDA FS estimates. Agricultural crops: USDA Statistical Reporting Service, Crop Reporting Board 1987.

for veneer logs was 1.4 billion cubic feet (8.2%); hardwood roundwood produced for the same purpose was 107 million cubic feet, or less than 1% of total harvest (fig. 30, Waddell et al. 1989: table 30).

Smaller and lower-grade trees are harvested as pulpwood to supply pulp, paper, and paperboard mills. In 1986, 3.1 billion cubic feet of softwood roundwood and 1.7 billion cubic feet of hardwood roundwood was harvested for pulpwood. This represents nearly 27% of total roundwood timber production (Waddell et al. 1989: table 30).



Source: Waddell et al. 1989; table 30

Figure 30.—Volume of roundwood timber products harvested, by type and species group, 1986.

Fuelwood for industrial and residential use has increased in importance during recent periods of high energy prices. The 1986 hardwood share of the roundwood fuelwood harvest accounted for over 82% of all fuelwood and 41% of the total hardwood roundwood harvest. Most roundwood fuelwood is used for residential heating, as industries usually rely on wood processing byproducts for fuel. A substantial amount of fuelwood is self-cut by households and comes from nongrowing stock sources that do not otherwise produce industrial timber (Skog and Watterson 1983, Rudis 1986). Markets for fuelwood are very diversified, and wide variations in prices exist, depending upon vendor, species, timing, condition, availability, and other factors. Consequently, fuelwood, although an important component of roundwood production, is very difficult to measure.

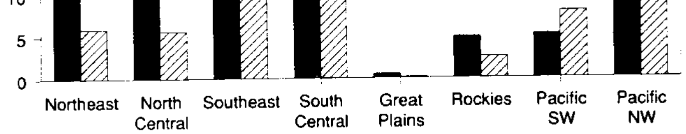
Production of roundwood for other products accounted for 6.1% of the total 1986 roundwood timber production (fig. 30). Other products include roundwood used for cooperage, pilings, poles, posts, shakes, shingles, charcoal, and export logs.

The value of these roundwood timber products varies greatly by product. Across all regions, the average price paid for softwood sawtimber and used for sawlogs and veneer logs is over three times higher than the price paid for softwood pulpwood, fuelwood, or miscellaneous products. The value of the total roundwood production in the United States was over $5 billion, with $4.8 billion attributable to softwood products and less than $1 billion to hardwood roundwood products (McKeever and Jackson 1990: table B-1). Softwood sawlogs accounted for 56% of the total value of all roundwood products; softwood veneer logs for 16%. Higher prices paid for softwood sawtimber, relative to softwood pulpwood, hardwood products and fuelwood account for much of this difference, as does the larger quantity of softwoods harvested. However, prices for scarce or premium hardwoods may be several times the average for either softwood sawtimber or mixed hardwoods.

Relative Importance of Regions

Generally, the roundwood output from individual supply regions represents the timber resources within each region. Historically, this has been demonstrated by cyclic levels of production across the country. As the timber resources of a region became economically accessible production increased, peaked, and eventually declined. The result has been a gradual westward movement, from the northern and southern regions, into the Midwest, then eventually spreading throughout the West. Concurrent with the reduction of the supply of high quality, old-growth timber in the Pacific Coast, the abundant timber supplies in the South have again matured, offering new opportunities for increasing roundwood production in this region. Consequently, a shift from roundwood production in the West back to the South has been slowly occurring in the last several decades.

Roundwood production in 1986 came primarily from three subregions (fig. 31). The Southeast subregion provided 21.2% of all roundwood production, the South Central 24.7%, and the Pacific Northwest 20.3% of total production. The combined northern subregions provided 23.2%, and the Rockies and Pacific Southwest subregions each contributed 5% of the total roundwood produced in 1986. Over 65% of the 1986 roundwood production in the two southern regions came from softwood species, while in the Pacific Northwest, softwoods provided over 96% of the total harvest.



Source: Waddell et al. 1989; table 30

Figure 31.—Percentage volume and value of roundwood timber products harvested, by region and subregion, 1986.

In terms of the value of this roundwood produced, the gap between the combined Southeast and South Central subregions (48.2%) and the Pacific Northwest subregion (29.3%) is smaller (McKeever and Jackson 1990: table B-1). Again, this is due to differences in the regional characteristics of the available timber resources. Since the harvest in all three of these subregions is predominately softwoods, the stumpage prices paid for roundwood is heavily weighted by higher softwood roundwood stumpage prices, especially in the Pacific Northwest.

Relative Importance of Regional Products

Nationwide, sawlogs and pulpwood are the major roundwood products produced. Regionally and subregionally, the importance of these two outputs varies. Sawlog production is ranked first in the Pacific Northwest, Rockies, Pacific Southwest, and Alaska subregions. In both the Southeast and South Central subregions, pulpwood production is the major roundwood output, while in the Northeast and North Central subregions, fuelwood is the major component of total regional roundwood production. These rankings demonstrate the effects of regional timber supply characteristics, as do the regional softwood-hardwood proportions of the total roundwood harvest.

Sawlog production in the West (Pacific Coast and Rocky Mountain regions) is composed primarily of softwood species, averaging over 95% of total sawlog production (Waddell et al. 1989: table 30). Pulpwood production in the South is also predominately from softwood species, averaging about 67%. Fuelwood production in the North, however, is over 92% hardwoods.

The estimated value of these regional outputs reflects both regional timber characteristics and relative valuations placed on those outputs. The timber economy of the Western regions is largely supported by softwood sawlog outputs, which accounted for 38% of the value of all sawlog production and 26% of the value of all roundwood production. The Pacific Northwest subregion was responsible for most of this, providing over 27% of the value of sawlogs and 29% of the value of all roundwood production (McKeever and Jackson 1990: table B-1).

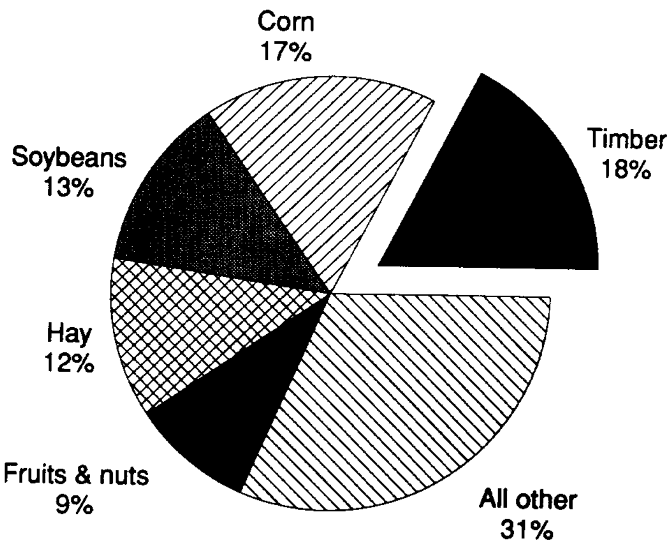
Sawlog values, as a percent of the value of total roundwood, are almost equal in the Southeast (15%) and South Central (17%) subregions. The value of veneer logs in these two subregions is higher than the value of pulpwood, although the volume of pulpwood production is greater. Similarly, although much of the roundwood harvest in the Northeast and North Central subregions is fuelwood, the valuation of this roundwood output is low.

Value of Timber Products Compared with Agricultural Crops

Timber products comprise a large part of the total value of agricultural crops produced in the United States annually. In 1986, roundwood timber products, at local points of delivery, were valued at $12.6 billion, compared to $59.4 billion for other agricultural crops (table 51). Timber products value at local points of delivery are defined here to be timber products output volumes multiplied by estimated stumpage prices and logging and hauling costs. Timber products were valued at about 21% of the value of other agricultural crops; for every dollar of timber products produced, about $4.75 of other agricultural crops were produced.

In addition to timber, there are 28 individual agricultural crops identified by the Crop Reporting Board of the USDA Statistical Reporting Service. Timber was the single, highest-valued crop produced in the United States in 1986. Timber (at $12.6 billion) exceeded corn, the second largest crop valued at $12.4 billion, by $200 million (McKeever and Jackson 1990: table B-2). Timber accounted for 18% of total crop values; corn 17% (fig. 32). Just three other crops—soybeans, hay, and fruits and nuts—had values of more than half that of timber. The remaining 25 crops had values less than half the timber value, 18 crops had values less than 10% of timber.

The relative importance of timber compared to other agricultural crops varies by region and subregion of the country. Timber is the highest valued crop in the South, the Pacific Northwest, and in Alaska (table 52). The value of timber in the South is more than three times that of tobacco, the second highest valued crop. Within the two southern subregions, timber values are about twice that of the second largest crops. Since the second largest crops are different in each of the two southern subregions, combined timber values for the region far exceed other crop values for the South as a whole.



Sources: see table 51

Figure 32.—Percentage value of roundwood timber products and other major agricultural crops, 1986.

As in the South, timber is the highest valued crop in the Pacific Northwest subregion, and in Alaska. Timber values in both exceed the combined value of all other crops produced there, and timber values in the Pacific Northwest exceed timber values in all other regions (table 52). In the Pacific Southwest, timber ranks third, well below fruits and nuts, and vegetables. The large

Table 52.—Estimated values at local points of delivery of roundwood timber products[1] and the highest valued agricultural crops[2] in the United States, by region and subregion, 1986.

Region and subregion	First Crop	First Value	Second Crop	Second Value	Third Crop	Third Value	Fourth Crop	Fourth Value	Fifth Crop	Fifth Value
					Million dollars					
North	Corn	8,887	Soybeans	6,725	Hay	3,672	Timber	1,627	Fruit & nut	802
Northeast	Hay	1,093	Timber	867	Fruit & nut	511	Corn	472	Vegetables	267
North Central	Corn	8,415	Soybeans	6,602	Hay	2,579	Timber	760	Wheat	648
South	Timber	5,110	Tobacco	1,690	Soybeans	1,641	Hay	1,630	Cotton	1,451
Southeast	Timber	2,311	Fruit & nut	1,317	Tobacco	1,033	Peanuts	749	Vegetables	740
South Central	Timber	2,799	Cotton	1,349	Hay	1,300	Soybeans	1,222	Wheat	790
Rocky Mountains	Wheat	2,666	Hay	2,323	Corn	2,265	Soybeans	960	Timber	804
Great Plains	Corn	2,052	Wheat	1,838	Hay	1,055	Soybeans	960	Sorghum	608
Rockies	Hay	1,268	Wheat	827	Timber	789	Potatoes	517	Barley	393
Pacific Coast	Timber	5,082	Fruit & nut	4,109	Vegetables	2,216	Hay	1,022	Cotton	665
Pacific Southwest	Fruit & nut	3,331	Vegetables	1,980	Timber	1,032	Cotton	665	Hay	617
Pacific Northwest[3]	Timber	3,946	Fruit & nut	778	Wheat	429	Hay	402	Potatoes	355
Alaska	Timber	104	Hay	3	Potatoes	2	Barley	1	Oats	[4]
United States	Timber	12,624	Corn	12,387	Soybeans	9,326	Hay	8,647	Fruit & nut	6,520

[1]*Includes logs, bolts, or other round sections cut from trees.*
[2]*Includes field crops, fruits and nuts, and vegetables of commercial significance.*
[3]*Data for the Pacific Northwest-West and Pacific Northwest-East subregions are not available.*
[4]*Less than $500,000.*
Source: See table 51.

areas of irrigated crop lands in Southern California account for the importance of these two agriculture crops over timber.

Timber values in the North and the Rocky Mountain regions are small compared to other agriculture crops, and to timber in other regions of the country. In both the Northeast and North Central subregions, timber production is valued at well below $1 billion (table 52). For the North region, timber ranks fourth at $1.6 billion. As expected, timber is not an important crop in the Great Plains subregion of the Rocky Mountains, but it ranks third in the Rockies below hay and wheat. For the Rocky Mountain region, timber's rank drops to fifth due to the large impact of Great Plains' field crop production.

From these comparisons, it is apparent that timber is an important, vital crop in the United States. It is the single most important agricultural commodity in many areas of the country, with changes in production levels or prices dramatically affecting local, state, and regional economies.

Contribution of All Forest Industries to Regional and National Economies

The volume and value of roundwood timber products are two indicators of the contribution to the economy made by roundwood timber. Roundwood production levels, stumpage payments made to landowners, and payments made to transport roundwood to processing sites represent both employment and income resulting from utilization of the Nation's forest resources at the harvesting stage. Every year, the sale of U.S. Forest Service timber generates a return of 25% of gross revenue to the counties where harvest occurred.[12] This money is allocated to roads and schools in these counties and represents a significant contribution to many counties throughout the Nation.

Scope of Forest Industry Manufacturing

The wood manufacturing industries rely on the roundwood forest resource for income and employment. Industries such as sawmills and paper mills process roundwood directly into lumber, newsprint, and other marketable primary wood products. Some industries purchase these products to manufacture more highly finished, secondary goods, such as cabinets, furniture, pallets, paper bags, and high-grade paper products. Producers of gum and wood chemicals also rely on timber for raw materials.[13]

The 1986 Annual Survey of Manufacturers (USDC BC 1988b) is used for information on employment, wages and salaries, value of shipments, and value added from manufacture. These measures serve as indicators of the effects the forest industries have on regional and national economies. Most are self explanatory but value added is a net measure of an industry's contribution to the economy because the value of materials received from other firms and used in the manufacturing process is subtracted from the value of the products shipped.

Contributions to the National Economy

The forest industries are a vital component of the Nation's economy. About 8% of all employment, wages and salaries, value added by manufacture, and value of shipments by all manufacturers were directly attributable to the forest industries in 1986 (table 53). This translates to a workforce of more than 1.6 million employees earning nearly $34.3 billion. Industry shipments were valued at $185.8 billion, with $83.4 billion being value added.

In terms of the gross national product, forest industries wages and salaries were less than 1% and the value of shipments was 4.4% of GNP in 1986. In total, over 5% of the gross national product is derived from the production of the forest industries, as measured by these indicators.

Contributions to Regional Economies

The contributions made by forest industries, in comparison to all manufacturing industries, to regional economies vary widely. The North, which is relatively more industrialized than other regions, is less dependent on the forest industries for economic stability than the South and Pacific Coast where the forest industries represent a larger proportion of all manufacturing. The Rocky Mountain region has about the same proportional contribution to manufacturing by the forest industries as does the North, but in absolute terms, is less than a tenth the size of the North.

Economies in the Northeast and North Central subregions of the North received nearly equal contributions from their forest industries. These are the two largest subregions in the United States in terms of both total manufacturing and forest industries manufacturing. Forest industries in the Northeast accounted for about 6% of all employment, wages and salaries, value added by manufacture, and value of shipments (table 53). Forest industries in the North Central subregion contributed 8% of employment, and about 7% each of wages and salaries, value added by manufacture, and value of shipments.

The South is the region most dependent on the forest industries for its economic well-being, even though its individual subregions rank only third and fourth among all subregions in the percentage contribution by forest industries to all manufacturing. The total size of the forest industries in the South is nearly equal to that in the North, but all other manufacturing is considerably

[12]The sale of Bureau of Land Management timber returns 50% of gross revenues to the counties where harvest occurs.

[13]Using the two-digit Standard Industrial Classification (SIC) code (Office of Management and Budget 1972), the Forest Industries are defined here to be lumber and wood products (SIC 24), furniture and fixtures (SIC 25), paper and allied products (SIC 26), and Industry 2861—gum and wood chemicals.

Table 53.—Employment, wages and salaries, value added by manufacture, and value of shipments for all manufacturing and for forest industries,[1] by region and subregion 1986.

Region and subregion	Employment[2] All industries	Employment[2] Forest industries		Wages and salaries[2] All industries	Wages and salaries[2] Forest industries	
	Thousands		*Percent*[3]	*Million dollars*		*Percent*[3]
North						
Northeast	4,739.4	307.9	6	119,205.1	6,629.2	6
North Central	5,036.4	381.6	8	135,744.3	8,630.9	6
Total	9,775.8	689.5	7	254,949.4	15,260.1	6
South						
Southeast	2,585.1	340.9	13	51,444.7	6,225.0	12
South Central	2,656.0	288.8	11	58,557.4	5,635.5	10
Total	5,241.1	629.7	12	110,002.1	11,860.5	11
Rocky Mountains						
Great Plains	315.7	16.3	5	6,985.8	302.0	4
Rockies	567.7	48.2	8	13,701.7	931.3	7
Totai	883.4	64.5	7	20,687.5	1,233.3	6
Pacific Coast						
Pacific Southwest	1,996.7	143.0	7	52,719.5	3,025.1	6
Pacific Northwest[4]	474.4	116.0	24	12,447.7	2,842.9	23
Alaska	8.8	1.3	15	230.5	39.2	17
Total	2,479.9	260.3	10	65,397.7	5,907.2	9
United States	18,380.2	1,644.0	9	451,036.7	34,261.1	8

Region and subregion	Value added by manufacture[2]			Value of shipments[2]		
	Million dollars		*Percent*[3]	*Million dollars*		*Percent*[3]
North						
Northeast	256,713.5	15,787.0	6	495,877.2	33,743.1	7
North Central	302,304.0	21,193.2	7	682,008.4	44,756.9	7
Total	559,017.5	36,980.2	7	1,177,885.6	78,500.0	7
South						
Southeast	134,488.3	15,085.0	11	286,570.9	34,374.0	12
South Central	150,948.3	14,444.4	10	385,640.2	33,281.2	9
Total	285,436.6	29,529.4	10	672,211.1	67,655.2	10
Rocky Mountains						
Great Plains	19,272.9	740.7	4	51,668.6	1,681.7	3
Rockies	31,875.0	2,018.3	6	64,888.7	4,849.2	7
Total	51,147.9	2,759.0	5	116,557.3	6,530.9	6
Pacific Coast						
Pacific Southwest	114,142.3	7,080.9	6	227,603.4	15,602.1	7
Pacific Northwest[4]	26,076.7	6,995.6	27	66,057.3	17,389.7	26
Alaska	501.2	63.7	13	2,014.7	135.3	7
Total	140,720.2	14,140.2	10	295,675.4	33,127.1	11
United States	1,036,322.2	83,408.8	8	2,262,329.4	185,813.2	8

[1]*Includes logging contractors and manufacturers whose primary products include softwood and hardwood rough and dressed lumber, flooring, dimension stock, railroad ties, furniture frames, wood lath, wood chips, pulp, paper, paperboard, building paper and board, veneer, plywood, millwork, wood furniture and fixtures, wood containers, pallets, prefabricated wood structures and mobile homes, shingles, excelsior, particleboard, gums and wood chemicals, wood preserving, and converted paper and paperboard products.*

[2]*Data may have been withheld to avoid disclosure.*

[3]*Forest industries as a percent of all U.S. industries.*

[4]*Data for the Pacific Northwest-West and Pacific Northwest-East subregions are not available.*

Note: Data may not add to totals because of rounding.

Source: USDC BC 1988b.

smaller making the proportional contribution by the forest industries greater in the South. For example, forest industry employment in the North and South regions was nearly equal at .69 and .63 million, while employment in all industries was nearly twice as much in the North as in the South (table 53, fig. 33). Employment was 13 and 11% of all manufacturing; wages and salaries, value added by manufacture, and value of shipments were about 12% and 10%, respectively, in the Southeast and South Central subregions.

The Rocky Mountain region is a diverse mixture of geographical types, including primarily agricultural lands in the Great Plains subregion, and forest lands in the Rockies subregion. The makeup of the forest industries in the region reflect this diversity. Proportionally, the Great Plains subregion has the smallest forest industry. Just 5% of all manufacturing employees are in the forest industries, and about 4% of manufacturing wages and salaries, value added, and value of shipments originate in the forest industries. Manufacturing in the Rockies subregion is much more dependent on the forest industries. Eight percent of all employees, and about 7% of all wages and salaries, value added by manufacture, and value of shipments from manufacturing result from the forest industries.

The Pacific Coast is the second largest region in the proportional contribution of its forest industries to total manufacturing. Much of this is directly attributable to the Pacific Northwest subregion. The Pacific Northwest is a major timber producing area, with its economy being dependent on forest industries. This dependency is reflected in the four measures reported here. Forest industry accounts for 24% of all employment (table 53), 23% of the wages and salaries, 27% of the value added by manufacture, and 26% of the value of shipments. These last three measures are the highest shares in any region or subregion.

The percentage distribution in the Pacific Southwest is nearly identical to that in the Northeast. Seven percent of employment, and about 6% each of wages and salaries, value added by manufacture, and value of shipments are accounted for by forest industries in this subregion.

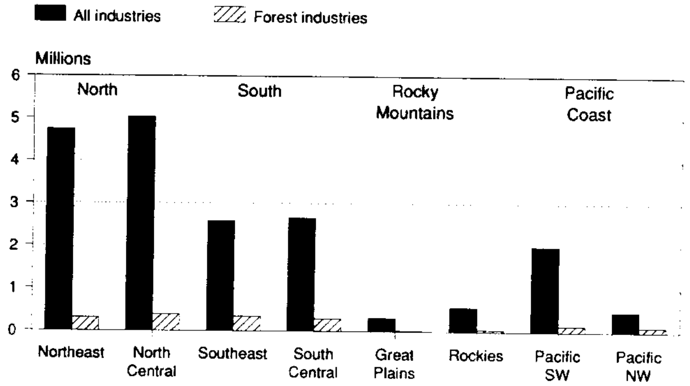
Although Alaska has the lowest measures for all industry and forest industry activity of all subregions, it ranks second only to the Pacific Northwest in contributions by forest industries to its manufacturing economy. Fifteen percent of all manufacturing employment in Alaska is in the forest industries, reflecting the importance of timber. Seventeen percent of total wages and salaries, 13% of the value added by manufacture, and 7% of the value of shipments are due to forest industry activity in Alaska.

CHARACTERISTICS OF THE PRIMARY TIMBER PROCESSING INDUSTRIES

The Nation's timber processing industries can be divided into seven primary industries based on the types of products produced. These primary timber processing industries include logging and harvesting operations; producers of solid-wood commodities such as softwood and hardwood lumber, structural and nonstructural panels, and a wide variety of other wooden products such as pallets, treated fence posts, ladders, and picture frames; as well as producers of fiber-based commodities such as pulp, paper and paperboard. Information for each of these groups was compiled, in part, from data reported in the periodic Census of Manufacturers and in the annual Survey of Manufacturers conducted by the U.S. Department of Commerce, Bureau of the Census. The most recent Census of Manufacturers was conducted in 1982; the most recent Survey of Manufacturers in 1986. The following list shows the composition of the timber processing categories used here, based on SIC industry and product groupings:

Primary timber processing industry	**SIC code**	**SIC industry or product**
Timber harvesting	2411	Logging camps and contractors
Lumber	2421	Sawmills and planing mills, general
	2426	Hardwood dimension and flooring
	2429	Special product sawmills, not elsewhere classified
	2448	Wood pallets and skids
Structural panels	2436	Softwood veneer and plywood
	24922	Waferboard and oriented strand board
Nonstructural panels	2435	Hardwood veneer and plywood
	24996	Hardboard
	26611	Insulating board
	24921	Particleboard
	24993	Medium-density fiberboard
Other primary timber	2441	Nailed wood boxes and shook
	2449	Wood containers, not elsewhere classified
	2491	Wood preserving
	2499	Wood products, not elsewhere classified, except hardboard and medium-density fiberboard
Wood pulp	2611	Pulpmills
Paper and paperboard	2621	Paper mills, except building paper
	2631	Paperboard mills
	2661	Building paper and board mills, except insulating board

Source: Office of Management and Budget 1972



Source: USDC Bureau of the Census 1988b

Figure 33.—Employment in all industries and forest industries, by region and subregion, 1986.

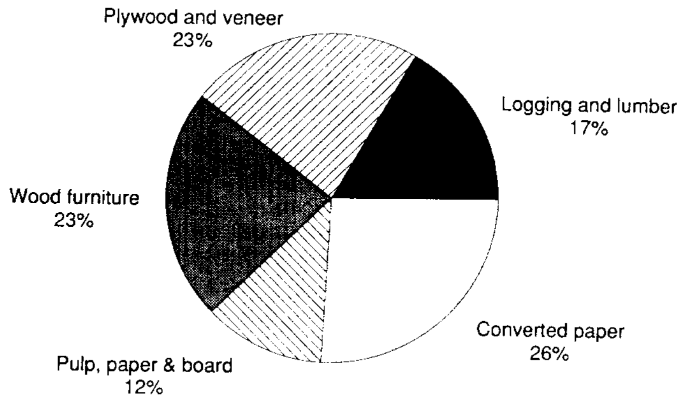


Figure 34.—Percentage employment in the timber processing industries, by industry, 1986.

Relative Importance of Various Industries

These seven industries can be grouped into five to better understand and compare them. These five timber processing industries are: the logging and lumber industry; plywood, veneer, and other wood products industry; wood furniture and fixtures industry; pulp, paper, and board industry; and the converted paper and paper board industry.

Four economic measures can be used to assess the relative importance between the timber processing industries. Employment in each of the 5 timber processing industries ranges from a high of more than 400 thousand (26% of total employment) in the converted paper and paperboard industry; to a low of under 200 thousand (12% of total employment) in the pulp, paper and board industry in 1986 (table 54, fig. 34). Employment levels reflect the nature of the end product, more than the number of establishments or extent of capitalization. For example, those industries producing largely secondary or consumer products such as furniture and fixtures, or paper products, tend to have more employees than those producing mostly primary or intermediate products such as lumber, plywood, containers, or woodpulp.

Total wages and salaries paid out in 1986 exceeded $32 billion (table 54). The converted paper and paperboard industry paid the highest total wages and salaries ($9.3 billion), followed by the pulp, paper, and board industry ($6.8 billion). Average compensation per employee, a measure of relative differences between industries, was higher in the two fiber-based industries than in the three solid-wood-based industries. Higher average compensation in the paper industries reflects many characteristics of the industry, including the need for better trained employees, the corporate nature of mill ownership, the degree of unionization of the labor force, and relatively stable levels of consumption for the end product.

Value added by manufacture in all timber processing industries totaled nearly $80 billion 1982 dollars in 1986; value of shipments was nearly $180 billion (table 54). The two paper industries accounted for over half of the value of all shipments, with more than half of these being converted paper and paperboard products. Value added per dollar of shipments measures the contribution of the industry to the end product. Industries which produce primary products or commodities tend to add less value to the product in manufacturing than those

Table 54.—Employment, wages and salaries, value added by manufacture, and value of shipments in the timber processing industries, 1986.

Industry	Employment	Wages and salaries	Value added by manufacture	Value of shipments
	Thousands		*Million 1982 dollars*	
Logging and lumber	263.3	4,485.5	9,994.8	26,130.8
Plywood, veneer, and other wood products	359.1	6,376.1	13,402.5	32,403.5
Wood furniture and fixtures	356.8	5,758.2	12,251.9	23,399.5
Pulp, paper, and board	197.5	6,760.4	18,668.8	40,932.8
Converted paper and paperboard	405.1	9,320.3	25,168.1	56,725.0
Total	1,581.8	32,700.5	79,486.0	179,591.6

Source: USDC BOL 1988.

producing secondary or consumer goods. Further, the value of an end product such as furniture, is more dependent on the manufacturing process than the value of the raw material used to produce it. In 1986, 52% of the value of wood furniture and fixtures shipments were a result of value added, as opposed to 38% in the logging and lumber industry. All industries averaged 44% of the value of industry shipments resulting from the manufacturing process.

National Characteristics

Industry Characteristics

The primary timber processing industries in the United States employed more than 600 thousand persons in 1986, and paid out nearly $14 billion in wages and salaries, measured in 1982 dollars (table 55). Total industry shipments were valued at nearly $81 billion, of which $34 billion was added by manufacture. Timber harvesting, lumber manufacturing and other primary timber processing accounted for 56% of all employment and 39% of the value of all shipments originated in 1986 (McKeever and Jackson 1990: table B-5). Structural and nonstructural panels, woodpulp, and paper and paperboard industry groups accounted for 44% of employment and 61% of the value of all primary timber products shipped.

During the 1980s, most industries experienced reductions in employees and constant-dollar value of shipments. The only increases were in the number of employees in the woodpulp industry. The solid-wood industries (lumber and structural panels) were most severely impacted. These declines cannot be completely blamed on the 1982 economic recession. Long-term trends in the primary timber processing industries have been towards larger mills with fewer employees producing goods with increasing real total value and value per employee (figs. 35 and 36). These long-term trends are evident in 1986 as total employment remained near the 1982 low, but constant dollar shipments and shipments per employee rose to record levels.

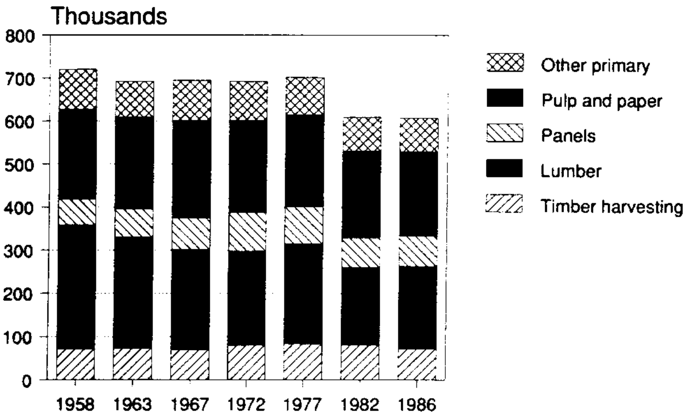
Organization

Overall, establishments in the primary timber processing industries tend to be small and to operate as single-unit companies. The timber harvesting, and lumber and other primary timber manufacturing dominate the primary timber processing industry. Overall industry trends in establishment types are largely determined by these three groups. The remaining primary processors, those producing structural panels, nonstructural panels, woodpulp, and paper and paperboard, tend to be large establishments operated by multi-unit companies.

Table 55.—Employment, wages and salaries, value added by manufacture, and value of shipments in the primary timber processing industries, 1986.

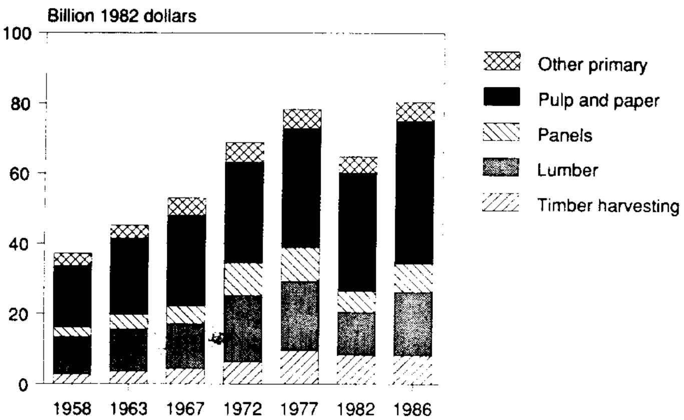
Industry	Employees	Wages and salaries	Value added by manufacture	Value of shipments
	Thousands	*Million 1982 dollars*		
Timber harvesting	72.3	1,247.5	2,886.5	8,219.3
Lumber manufacturing	191.0	3,238.0	7,108.3	17,911.6
Structural panel manufacturing				
Softwood veneer and plywood	35.9	824.5	1,675.0	4,392.3
OSB/waferboard	2.5	87.1	393.2	664.8
Total	38.4	911.6	2,068.3	5,057.1
Nonstructural panel manufacturing				
Hardwood veneer and plywood	17.0	268.2	630.7	1,582.0
Hardboard, insulating board, particleboard, and medium-density fiberboard	14.3	274.7	642.8	1,587.7
Total	31.3	542.8	1,273.6	3,169.8
Woodpulp manufacturing	15.3	592.5	1,587.6	3,829.6
Paper and paperboard manufacturing				
Newsprint	10.7	321.5	1,088.0	2,524.0
Other paper	118.6	4,100.0	10,949.7	23,202.0
Paperboard	51.0	1,710.5	4,937.3	11,138.0
Total	180.3	6,131.9	16,975.0	36,864.0
Other primary timber manufacturing	79.0	1,117.3	2,392.4	5,502.0
Total, primary timber processing	607.6	13,781.7	34,291.6	80,553.3

Note: Data may not add to totals because of rounding.
Source: USDC BC 1988b.



Source: USDC Bureau of the Census 1971, 1987.

Figure 35.—Employment in the primary timber processing industries, by industry, specified years 1958–1986.



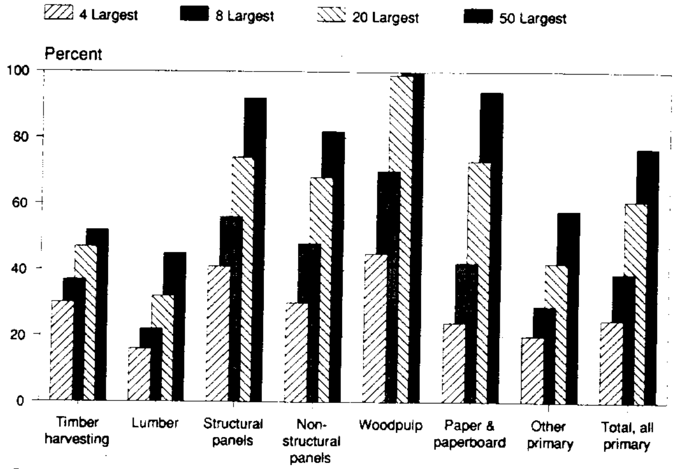
Source: USDC Bureau of the Census 1971, 1987.

Figure 36.—Value of shipments in the primary timber processing industries, by industry, specified years 1958–1986.

The most common legal form of organization in the primary timber processing industries is noncorporate, individual ownership. Again, overall trends are largely dependent on the timber harvesting, lumber, and other primary timber industries. Timber harvesting is the only industry where noncorporate ownership prevails. The level of incorporation in the other industries varies from about half for the lumber industry to complete incorporation for the woodpulp industry. Differences between the industries reflect, to some extent, the levels of capital needed to build, operate, and maintain equipment and production facilities.

Concentration

One way to view industry structure is to measure how much output is accounted for by some specified number of the largest companies. Using the average for all primary timber processing industries,[14] 25% of the value of shipments of all companies was accounted for



Source: USDC Bureau of the Census 1985.

Figure 37.—Percentage of value of shipments in the primary timber processing industries, by company size and industry, 1982.

by the 4 largest companies (fig. 37). In the structural panels and the woodpulp industries, the 4 largest companies accounted for 41 and 45%, respectively, of the value of shipments. The 4 largest companies in the lumber and the other primary timber products industries accounted for just 16 and 20%, respectively, of the value of industry shipments.

When looking at the proportions accounted for by the eight largest companies, these relative rankings remain the same. The average value of shipments of all primary timber processing industries accounted for by the 8 largest companies within each industry group in 1982 was 39%. In the structural panels and woodpulp industries, 56 and 70%, respectively, of the value of shipments were attributed to the 8 largest companies. The value of shipments by the 8 largest companies for lumber manufacturing and the other primary timber industries accounted for just 22 and 29%, respectively. These proportions reflect the more capital-intensive nature of the panel and pulp industries compared to the lumber and other primary timber industries.

In 1982, the 50 largest primary timber processing companies accounted for 77% of all industry shipments (fig. 37), compared to 70% in 1972. Patterns of shipments by company size within the individual industry groups are similar to the patterns stated above. Approximately one-half of the value of all shipments in the timber harvesting, lumber, and other primary timber industries were accounted for by the 50 largest companies. In contrast, over 80% of all shipments in the remaining industries—structural panels, nonstructural panels, and the paper and paperboard industries—were accounted for by the 50 largest companies (fig. 37). The 20 largest woodpulp-producing companies accounted for 99% of industry shipments.

Regional Capacity

Primary timber processing industries usually locate close to raw material supplies, thereby reducing acqui-

[14] *This section is based on data from the 1982 Census of Manufacturers (USDC BC 1985) which is the most recent source of this data.*

sition and transportation costs, and ensuring timber supply sources. Differences in roundwood supplies influence the types of industries located within each region. Timber species, size, and quality; ownership and size of timber tracts; accessibility and quality of transportation networks; and the general availability of timber are all influencing factors.

Information on the productive capacity of the primary timber processing industries for 1985 (table 56) was available for four industries: lumber, softwood plywood, woodpulp, and paper and paperboard manufacturing. By their nature, the remaining industries—timber harvesting, nonstructural panels, and other primary timber—do not lend themselves to aggregated measures of industry capacity. The South ranks first in capacity for woodpulp, and paper and paperboard production, and second in lumber manufacturing capacity. Structural panel capacity is nearly equal in the South and Pacific Coast regions. The Pacific Northwest subregion had more lumber manufacturing capacity than any other single region or subregion. Lumber manufacturing capacity in this region in 1985 exceeded that of the Southeast, the second largest subregion, by 50%. The North ranked second in both woodpulp, and paper and paperboard capacities in 1985.

Significant Changes in the Last Decade

Two distinct changes occurred in the primary timber processing industries in the last 10 years. The first was a change in raw material supplies, which has affected all industries and their products. Depletion of the old-growth timber and the removal of large tracts of national forest lands from timber production in the West have shifted production away from large diameter sawlogs and veneer logs to smaller diameter logs with different utilization characteristics in those regions. During the same period, the availability and utilization of Southern pine roundwood has increased. For both Southern subregions, this has altered harvest by landowner class, the quality of available roundwood, and in the extreme, location of individual firms. During the last decade, a few large, integrated firms physically moved their headquarters from the Pacific Northwest to the South in response to these changes in raw material supplies.

The second significant change in the last decade has been the increasing adoption of new technologies by all industries. These technologies usually focus on either increasing product recovery or reducing labor requirements, both of which result in improvements in efficiency. For solid-wood products, the economic recession

Table 56.—Annual production capacity for specified primary timber processing industries in the United States, by region and subregion, 1985–86.[1]

Region and subregion	Lumber	Softwood plywood	Woodpulp	Paper and paperboard
	Million board feet (lumber tally)	*Million square feet (3/8-inch basis)*	*Thousand tons*	
North				
Northeast	NA	NA	4,849	11,754
North Central[2]	NA	NA	4,614	14,100
Total	NA	NA	9,463	25,854
South				
Southeast	6,945	3,710	19,227	18,901
South Central	5,865	8,975	21,800	21,706
Total	12,810	12,685	41,027	40,607
Rocky Mountains[3]	5,075	1,240	736	1,512
Pacific Coast				
Pacific Southwest	4,900	325	1,182	2,501
Pacific Northwest	13,625	11,000	7,846	7,447
Pacific Northwest-West	10,440	10,150	NA	NA
Pacific Northwest-East	3,185	850	NA	NA
Alaska	377	NA	433	NA
Total	18,902	11,325	9,461	9,948
United States	36,410	25,250	60,686	77,921

NA—Not available.
[1]Average annual capacity for the 2-year period.
[2]Includes the Great Plains subregion.
[3]Includes both the Rockies subregion and western South Dakota.
Sources: Lumber and softwood plywood: Adams et al. 1987. Woodpulp, and paper and paperboard: American Paper Institute 1987a, Vance Publishing Corp. 1988. Alaska: USDA FS 1988d.

of the early 1980s accelerated this process by eliminating inefficient operations and forcing plant closures or renovations to remain competitive. Some plants that did close were sold, remodeled, and then reopened as more efficient operations. Examples of technological change include the adoption of lasers and computerized green chains in sawmills, the power back-up roll and spindleless lathe now in use in plywood plants, and new processes to produce woodpulp at higher recoveries and with less pollution. For several industries, the availability of new technologies has created opportunities for new products and new markets for old products. OSB/waferboard is one example of a new product that has matured during the last decade, reaching both new users and new markets.

The Timber Harvesting Industry

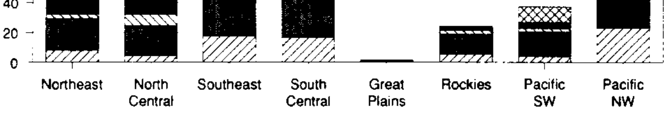
Industry Characteristics

Timber harvesting activities in the United States employed 72.3 thousand persons in 1986. Wages and salaries exceeded $1.2 billion, measured in 1982 dollars (table 55). Industry shipments were valued at $8.2 billion, with value added by manufacture accounting for 35% of industry shipments. The primary timber processing industries are value-added industries; timber harvesting provides the base for the remaining primary timber processing industries, accounting for about 10% of total economic activity of the primary timber processing industries.

Regional Characteristics

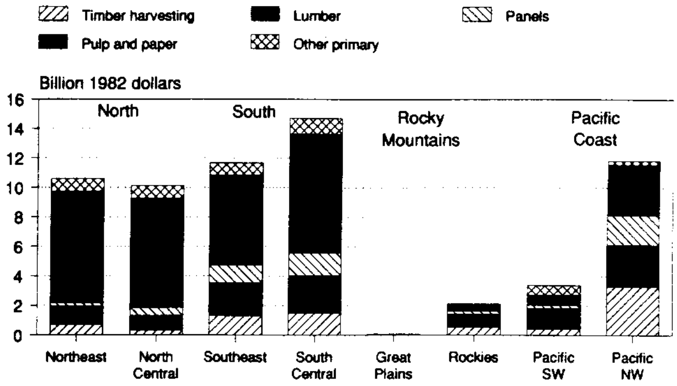
Regional characteristics of the timber harvesting industry reflect regional timber resource patterns and timber accessibility. In 1982, the South and North, with large acreages of readily accessible timber, employed 58% of the industry's work force (fig. 38), and had shipments valued at just 47% of the industry's total (fig. 39).

The Pacific Northwest-West subregion supports 58% of all timber harvesting employees and industry ship-



Source: USDC Bureau of the Census 1985, Adams et al. 1987.

Figure 38.—Employment in the primary timber processing industries, by region and subregion, 1982.



Source: USDC Bureau of the Census 1985, Adams et al. 1987.

Figure 39.—Value of shipments in the primary timber processing industries, by region and subregion, 1982.

ments within the Pacific Coast region. This subregion had 21% of all employees, and 29% of all industry shipments for the United States, underscoring its importance as a major timber supplier. Wages and salaries, and value added by manufacture were correspondingly high. Both the Pacific Southwest and the Pacific Northwest-East subregions had less than 10% each of the employees and value of shipments of this region. Timber harvesting in Alaska accounted for less than 2% of the total industry employees and the value of shipments in 1982. The two Rocky Mountain subregions each accounted for 7% or less of all industry totals in 1982 (McKeever and Jackson 1990: table B-6).

Harvesting Costs, Production, and Innovations

Differences between the cost structure for the timber harvesting industry in the Pacific Northwest compared to that in the South reflect regional timber resource differences. In 1985, the average cost of harvesting timber in the Pacific Northwest was nearly two times higher than in the South (McKeever and Jackson 1990: table B-8). Harvesting costs throughout the West reflect these same factors, although Alaska consistently faces much higher harvesting costs. Cost estimates for the Northern regions are not available. Convergence of regional harvesting costs is slowly occurring as the physical differences between regional timber bases decrease.

Since 1958, timber harvesting in the United States increased 49%, mostly in the South (McKeever and Jackson 1990: table B-9). Harvest in the western regions peaked in 1986 reflecting general economic conditions. In the East, where more roundwood is used in the pulp, paper, and paperboard industries, harvest levels have either remained stable or increased.

Several trends in the automation of timber harvesting have developed as changes in the resource have occurred. Widespread use of the feller-buncher and other mechanized harvesting equipment over much of the South has helped reduce harvesting costs in this region. As more second-growth timber becomes available for harvesting, new, smaller equipment has been designed and is now in use. Smaller stems and more trees per acre

Tractor logging and mobile loaders are becoming more widespread in the West.

have also influenced this development. Overall, automation of timber harvesting has been widespread and influential in reducing operating costs.

The Lumber Manufacturing Industry

Industry Characteristics

The lumber manufacturing industry includes hardwood and softwood sawmills, planing mills, dimension mills, flooring mills, special product sawmills that produce lumber and other sawn products for sale, as well as pallet manufacturers. Pallet manufacturers are included because many produce pallet parts from logs, bolts, and cants, and as such, are "captive" sawmills. The U.S. lumber manufacturing industry employed 191 thousand in 1986, and paid out $3.2 billion 1982 dollars in wages and salaries (table 55). Industry shipments were valued at $17.9 billion, with value added by manufacture exceeding $7.1 billion. Employment in lumber manufacturing was about one-third of total employment in primary timber processing; while all other characteristics represented about one-fifth of all primary timber processing.

Reductions in 1972 and 1977 partially reflect the economic recessions experienced during the seventies. Between 1977 and 1982, employment fell 22% and value of industry shipments fell 38%, before increasing in 1986 (McKeever and Jackson 1990: table B-5). The industry is still operating well below levels achieved in 1977. The pallet manufacturing sector remained relatively unchanged during this period.

Regional Characteristics

Regional characteristics of the lumber manufacturing industry, like those of the timber harvesting industry, reflect regional timber resource patterns, but to a lesser degree. The North accounts for only about one-third of the employment and economic activity in the East; the South the remaining two-thirds.

Lumber Production, Costs, and Innovations

Total lumber production in 1986 was 42% above the 1958 level, and 16% above 1977, the previous peak year (McKeever and Jackson 1990: table B-9). All regions follow this trend. In 1986, the South led all regions in lumber production with 37%, the Pacific Northwest subregion was second at 24%, and the North third at 19% of the total.

In 1985, capacity of the two Southern subregions was 35% of the U.S. total, and capacity of the Pacific Northwest subregion was 37% of the total (table 56). Capacity data for the Northern regions was not available. Average lumber manufacturing costs varied from a low of $92.08 per thousand board feet (MBF), lumber tally, for the South to a high of $113.22 per MBF lumber tally, for the Pacific Southwest subregion (McKeever and Jackson 1990: table B-8). Product recovery factors, in MBF lumber tally, per MBF log scale, were highest in the Pacific Northwest subregion (1.579), about the same for the remaining Western regions and subregions (1.3–1.45), and 1.370 for Southern subregions in 1985 (Adams et al. 1988). Recovery factors have continued to increase since 1952, indicating continuing improvements in processing technologies and techniques.

Increasing computerization at all stages of processing is increasing lumber recovery. Some of these improvements focus on improving the handling of eccentrically shaped logs. Others, such as optimizing edgers and trimmers or using saws with thinner kerfs, apply new technologies to old practices. Application of Saw-Dry-Rip technology has succeeded in improving lumber grade recovery and in producing structural lumber from hardwoods and from Southern softwoods. Many of these technologies are being applied nation-wide as mills are renovated.

As new technologies are applied to changing timber resources, the potential for new lumber products increases. The use of molded 2 x 4's, hardwoods for structural lumber, and edge-glued or laminated lumber will soon challenge the traditional softwood lumber products for market share. Other new products, such as combination solid-wood/flakeboard I-beams are beginning to penetrate markets for competing products, notably steel and concrete.

The Structural Panels Manufacturing Industry

Industry Characteristics

The structural panels industry consists of manufacturers producing softwood plywood, waferboard, and oriented strandboard. In 1986 the industry employed 38.4 thousand, with more than 90% of these being in the softwood plywood sector of the industry (table 55). Wages and salaries totaled $911.6 million 1982 dollars. Industry shipments were valued at $5.1 billion, with value added being $2.1 billion. Structural panels manufacturing accounts for about 6% of employment, wages and salaries, value added by manufacture, and industry shipments in all primary timber processing industries.

Separate data for the softwood veneer and plywood component of the structural panels manufacturing industry are not available from the Census of Manufacturers prior to 1972; data on the OSB/waferboard component are not available prior to 1982. However, softwood plywood data are good indicators for the structural panel industry because of their continuing domination of the industry. Between 1977 and 1982, the number of employees and the value of shipments of softwood veneer and plywood fell. During this period the value of shipments of softwood veneer and plywood dropped nearly 30% when measured in 1982 dollars (McKeever and Jackson 1990: table B-5). Employment fell 24%. These reductions are largely a result of the economic recession of the early 1980s. Between 1982 and 1986, the structural panel industry rebounded from the recession, with both employment and industry shipments increasing. The OSB/waferboard component of the industry increased proportionally much faster than the softwood veneer and plywood component. Industry totals in 1986 were below levels set in 1977.

Regional Characteristics

Regional characteristics of the structural panel manufacturing industry, like the timber harvesting and lumber industries, reflect the forest resource base. Timber volumes, size, quality, and cost dictate the types of panels that can be economically produced. Top quality, large-diameter Douglas-fir peeler logs are the preferred species in the Pacific Northwest-West subregion where much of the Nation's high quality, sanded, and specialty softwood plywood grades are produced (McKeever and Meyer 1983). Softwood timber in the South is ideally suited to sheathing-grade plywood production. Peeler logs are generally small-diameter, and low quality. Few differences exist between southern pine peeler logs and southern pine sawlogs. The North Central subregion, with its abundant, mature aspen forests, is rapidly becoming the dominant OSB/waferboard producing region (Crows 1987). New capacity in the structural panels manufacturing industry is expected to come from OSB/waferboard mills located in the North and South.

Capacity

Capacity in the softwood plywood industry peaked in 1980, then dropped 9% to its current level in 1986 (25.3 billion square feet, 3/8-inch basis) (table 56). In addition, over 3 billion square feet of OSB/waferboard capacity has been added (McKeever and Meyer 1983). Between 1965 and 1975, softwood plywood industry capacity grew at a rate of 3.7% per year. The number of active plants also increased, but at a rate lower than capacity, resulting in an increase in average plant size. Between 1975 and 1982, net additions to capacity slowed and the number of active plants declined nearly 8%. These declines, and the decline in the industry's operating rate, are partially due to the economic recession in the early 1980s. The softwood plywood industry normally operates at around 95% of capacity; in 1982 it was operating at 65% of capacity. The 1986 operating rate was about 90% of capacity.

Panel Production, Costs, and Innovations

Total structural panel production in 1986 was a record 25.6 billion square feet, 3/8-inch basis (McKeever and Jackson 1990: table B-9). This is an increase of 32% over the previous high mark set in 1977. Production costs for softwood plywood in all regions have dropped in recent years as labor costs have fallen, especially in the West. Panel production costs in the West were still about 15% higher than in the South, reflecting higher labor costs and other factors (McKeever and Jackson 1990: table B-8). However, Western production costs are slowly converging towards the lower costs of the South as labor costs continue to drop. Recovery factors in the Pacific Coast regions were also higher than those in the Rocky Mountains or the South (McKeever and Jackson 1990: table B-10).

Several new technologies have been instrumental in improving product recoveries for softwood plywood. The spindleless lathe, in combination with powered back-up rollers, peels smaller logs down to a 2-inch core. Powered nosebars also peel to a smaller core, reduce spinouts, and improve both veneer quality and recovery. Improvements in gluing and drying have also improved product quality and recovery.

Many changes have occurred in this industry in the last decade. The most notable is the commercial acceptance of OSB/waferboard as a structural panel and a substitute for softwood plywood in some applications, particularly exterior sheathing applications. By 1986, OSB/waferboard had captured 19% of all structural panel consumption; this share has continuously increased. Revisions to building codes have been and are being accepted throughout the United States to accommodate this and other new products used by the construction industries.

The Nonstructural Panels Manufacturing Industry

The nonstructural panels manufacturing industry consists of an interesting assortment of panel producers. Hardwood veneer and plywood is made from logs that are either peeled or sliced. Hardboard, insulating board, and medium-density fiberboard (MDF) are produced from defibrated/exploded or groundwood woodpulp and other nonwood fibers. Particleboard is made from chipped roundwood and processing residues and sawdust (McKeever 1979, Dickerhoof and McKeever 1979).

Industry Characteristics

Employment at all establishments producing nonstructural panels totaled 31.3 thousand in 1986, with wages and salaries totaling $542.8 million 1982 dollars (table 55). Industry shipments were valued at $3.2 billion; value added by manufacture $1.3 billion. In terms of employment, wages and salaries, value added, and value of shipments, the industry is nearly equally divided between hardwood veneer and plywood manufacturers and manufacturers of all other nonstructural panels. In terms of establishments, however, the industry is dominated by hardwood veneer and plywood manufacturers. In 1982, 306 of 403 establishments were hardwood veneer and plywood producers.

Since 1972, the number of nonstructural panels manufacturing establishments has declined steadily. Data for the industry are incomplete prior to 1972, but during the 10-year period from 1972 to 1982, the number of hardwood veneer and plywood plants fell from 366 to 306, and the number of other nonstructural panel plants fell from 114 to 97 (McKeever and Jackson 1990: table B-5), representing an 18% loss. Employment by all nonstructural panel manufacturers fell 28%, while the value of industry shipments, measured in 1982 dollars, fell 18%. These declines resulted largely from a trend toward importing more domestic hardwood veneer and plywood. This trend is expected to continue as long as foreign suppliers, primarily those in the Far East, continue to supply low-cost, quality panels.

Regional Characteristics

The pine and mixed-hardwood forests in the South contain the favored tree species for producing nonstructural panels. In 1982, the two Southern subregions had a total of 17.4 thousand employees and $1.4 billion of shipments (McKeever and Jackson 1990: table B-6). This represents approximately half of the industry's employees and shipments.

Panel Production, Costs, and Innovations

The combined production of hardwood plywood, insulating board, hardboard, and particleboard (including medium-density fiberboard) has more than doubled since 1958 (McKeever and Jackson 1990: table B-11). The recession of the early 1980s severely impacted nonstructural panel production. Production levels have not returned to pre-recession levels for any individual product except particleboard. Since 1977, product substitution has played an important role in the overall decline in production of individual products. For example, hardwood veneer and plywood production has declined steadily since 1972, being replaced by overlayed nonveneered panels in furniture applications, and paper and paperboard in container and shipping applications. None of these panel products have been very successful in penetrating new markets, but some substitutions have occurred within the industry. More hardwood plywood, for example, is now being manufactured with a particleboard core and hardwood veneer faces. Similarly, particleboard with a decorative paper face is substituting for hardwood panels in some traditional uses.

Many of the same new technologies being applied in the lumber and the structural panels industries are being used for nonstructural panels as well. The spindleless lathe, laser technologies, and computerization of mills are all being implemented to increase product recovery and reduce production costs.

The Woodpulp Manufacturing Industry

Industry Characteristics

The market pulp industry in the United States is relatively small, accounting for about 15% of all pulpmills (McKeever 1987a). Employment in 1986 at market pulpmills was 15.3 thousand, with wages and salaries totaling $592.5 million 1982 dollars. Shipments of woodpulp were valued at $3.8 billion in 1986, with value added by manufacture being $1.6 billion. The woodpulp manufacturing industry is the smallest primary timber processing industry in terms of numbers of establishments, but exceeds the nonstructural panels industry in total value of products shipped, value added and wages and salaries. Employment declined in 1986 after increasing steadily since 1972. Industry shipments, however, were at a record $3.8 billion 1982 dollars in 1986. The economic recession which seriously impacted the solidwood industries (lumber, structural panel, nonstructural panel, and other primary timber) had less impact on the woodpulp industry. Pulp and paper products are used primarily for packaging and personal consumption, and are less responsive to economic cycles than are solidwood products.

Organization

Economies of scale dictate that woodpulp mills must be large to be competitive. They are second only to paper and paperboard mills. In 1982, one-fifth of the establishments in the woodpulp industry had fewer than 50 employees, while over half had 250 or more employees. Woodpulp mills are almost entirely operated by multiunit companies and are entirely corporately owned. The woodpulp industry is one of the most highly capital-intensive of the primary timber processing industries.

Regional Characteristics

The South is by far the largest woodpulp producing region. Nearly two-thirds of all employment, wages and salaries, value added by manufacture and value of industry shipments originated in the South in 1982 (figs. 38 and 39). The large volumes of southern pine, and the large paper and paperboard industry located there support the market pulp industry. Most of the pulp produced is kraft market pulp, but pulp using cotton linters is also common (Vance Publishing Corp. 1988).

Sulfite, groundwood, and deinked pulp are produced in addition to kraft pulp. Shipments from the North were below those from the Pacific Northwest-West subregion. Shipments of sulfite and kraft market pulp from the PNW-West subregion were valued at more than one-half billion dollars in 1982. Production of dissolving market pulp is one of the major industries in Alaska. Two pulpmills located in southeast Alaska provide 3% of all employees and industry shipments for this primary timber processing industry.

Production, Costs, and Innovations

In 1986, the woodpulp industry operated at full capacity. Total woodpulp production, which includes production by mills integrated with paper and board mills, increased steadily between 1958 and 1986, with a 24% increase since 1977. Table 57 lists the major pulp grades for all U.S. mills and production volumes in the United States from 1958 through 1986.

Regional production costs vary widely by product mix and were not available for 1986, but a national average of $371 per ton was estimated by the American Paper Institute (1988). Pulp yields for 1986, by region, were estimated and are listed in McKeever and Jackson 1990: table B-10.

Like the industries mentioned previously, the woodpulp industry has readily adopted computerization and other new technologies. Improvements in bleaching technologies and chemical recovery have also lowered costs and improved quality. Concerns about energy consumption and the environment in the last decade have generated changes in waste handling and financial expenses on control measures, usually increasing capital or operating costs.

Changes in the relative cost structures of hardwood and softwood roundwood supplies have generated shifts from exclusively softwood pulp production to the use of increasingly greater amounts of hardwoods. Concurrent with this shift has been the development and adoption of technologies to better utilize hardwoods in pulp and paper production. These shifts in roundwood utilization have had some impacts on the other primary timber processing industries as well.

The Paper and Paperboard Manufacturing Industry

Industry Characteristics

The paper and paperboard industry is the largest single component of the primary timber processing industries. Although the number of mills is low, employment, wages and salaries, value added by manufacture, and value of industry shipments far exceed all other industries. Nearly a third of all employment, and half of all wages and salaries, value added, and value of shipments in 1986 originated in the paper and paperboard manufacturing industry (table 55). The number of paper and paperboard mills has been declining since 1958. Older, pollution-intensive mills are being replaced, abandoned, or renovated with new papermaking technologies. These new technologies not only reduce pollution levels, but also increase average mill size. Also, some pollution-intensive pulping processes, such as caustic soda, have been virtually eliminated.

Employment in the paper and paperboard industries generally increased through 1967 and has since steadily declined (McKeever and Jackson 1990: table B-5). The capital-intensive technologies which were responsible for increasing average mill size and decreasing pollution levels are also responsible for declining employment. Total constant-dollar industry shipments, which increased steadily through 1977, declined slightly in 1982 as a result of the economic recession, and increased again in 1986 to a record $36.9 billion. Shipments of individual products followed the same general trend. Newsprint and other paper grade shipments increased dramatically over 1977 levels; paperboard shipments increased only modestly. Paperboard production is closely tied to levels of manufacturing activity; therefore it is more responsive to general economic shifts than are other paper grades.

Table 57.—Pulp, paper, and paperboard production in the United States, by product and grade, specified years 1958–86.

Product and grade	Production 1958	1963	1967	1972	1977	1982	1986
	Thousand tons						
Woodpulp							
Sulfite	2,381	2,689	2,563	2,173	2,012	1,654	1,637
Sulfate							
Bleached[1]	5,099	7,829	10,326	14,218	15,728	19,660	23,982
Unbleached	7,647	10,502	13,894	17,792	18,436	17,995	21,559
Total	12,746	18,331	24,220	32,010	34,164	37,655	45,541
Mechanical							
Groundwood	2,890	3,468	3,885	4,639	4,268	3,751	3,092
Thermomechanical	NA	NA	NA	NA	583	1,459	2,498
Total	2,890	3,468	3,885	4,639	4,851	5,210	5,590
Semichemical	1,622	2,629	3,185	3,786	3,542	3,311	4,214
Dissolving and special alpha	929	1,371	1,448	1,656	1,533	1,115	1,249
Other	1,228	1,632	1,376	2,502	3,030	2,040	2,704
Total, woodpulp	21,796	30,121	36,677	46,767	49,132	50,986	60,935
Paper and paperboard							
Paper							
Printing & writing	6,230	8,174	10,131	12,221	14,014	15,554	19,821
Newsprint	1,771	2,215	2,711	3,670	3,926	5,042	5,693
Tissue	1,931	2,573	3,232	3,992	4,346	4,441	5,152
Packaging & industrial	3,656	4,337	4,870	5,553	5,811	5,197	5,174
Construction paper	1,298	1,453	1,503	1,915	1,852	798	302
Total, paper	14,887	18,752	22,447	27,351	29,948	31,033	36,143
Paperboard							
Unbleached kraft	5,055	6,621	9,180	13,277	13,676	14,535	17,708
Recycled	6,771	6,867	6,985	7,543	7,330	6,476	8,092
Semichemical	1,720	2,260	2,959	4,013	4,272	4,389	5,382
Solid bleached	1,939	2,491	2,962	3,689	3,728	3,665	4,276
Wet machine board	138	141	144	148	129	129	101
Total, paperboard	14,271	18,380	22,229	28,670	29,135	29,194	35,559
Total, paper and paperboard	29,158	37,132	44,676	56,021	59,083	60,227	71,702

NA – Not available.
[1]*Includes soda pulp.*
Note: Data may not add to totals because of rounding.
Sources: American Paper Institute 1987a, USDC BC 1987e, Ulrich 1988.

Organization

Paper and paperboard manufacturing establishments are large and virtually all are owned by multi-unit corporations. As in the woodpulp industry, mill size is largely determined by the economies of scale associated with capital investment. Mills processing in excess of 2,000 tons of woodpulp per day are common (McKeever 1987a). Nearly 90% of all mills are operated by multi-unit companies and nearly all companies are corporately owned.

Regional Characteristics

The North Region had more paper and paperboard employees than any other region in 1982, as well as the highest total wages and salaries, value added by manufacture and value of industry shipments (figs. 38 and 39). Many of the mills in the North are smaller than the national average, and produce higher-valued printing, writing, and sanitary papers from softwoods and mixed hardwoods (American Paper Institute 1987a). Establishments in the South numbered just slightly more than one-third those found in the North. However, the value of shipments from these mills was over 80% of the value of shipments from Northern mills. Southern mills are generally newer than mills in the North, and are much larger in terms of both employment and output. The largest mills in the United States are the kraft mills in the South. Southern mills produce about two-thirds paperboard, of which most is unbleached kraft, and one-third paper. Mills in the West are intermediate in size and output, and produce a fairly equal mix of paper and paperboard. Table 57 lists the major paper and paperboard grades and production volumes for U.S. mills between 1958 and 1986.

Production, Costs, and Innovations

The paper and paperboard industry operated at about 95% of capacity in 1986 and the four Eastern subregions hold over 85% total capacity and production. Production costs for the United States were estimated by the American Paper Institute (1988) at $364 per ton for all products in 1986 (McKeever and Jackson 1990: table B-8). Regional and national recovery factors are listed in McKeever and Jackson 1990: table B-10. A higher proportion of mechanical pulp is being used in newsprint production, improving yields and quality. Anthraquinone is now being used in kraft production, increasing yields and lowering bleaching and recovery costs.

A significant change has occurred in the type of raw material used in papermaking. Many firms are using a higher proportion of hardwoods in their paper production processes. This shift is continuing and new processing technologies are being utilized to support the greater use of hardwoods in the papermaking process.

New paper and paperboard products have successfully penetrated some traditional packaging markets. Most notable is the development and acceptance of aseptic packaging technologies, slowly replacing glass bottles and aluminum cans in the food industry. New absorbent and nonwoven products have entered personal hygiene markets. Demand for printing and writing papers has increased concurrent with the spread of personal computers, somewhat negating predictions of the "paperless office." Technologies that improve the preprinting quality of newsprint and fine papers have been widely accepted in the last decade.

The Other Primary Timber Manufacturing Industry

Industry Characteristics

The other primary timber manufacturing industry is a collection of manufacturers producing a wide variety of miscellaneous wooden products. Included are manufacturers of wooden boxes and box shook, barrels, baskets, cooperage and crates, dowels, lasts, ladders, picture frames, toothpicks, rolling pins, and many other turned and shaped wooden products. Wood preservation plants are also included in this category. Employment in 1986 was 79.0 thousand, with wages and salaries totaling $1.1 billion 1982 dollars (table 55). Value added by manufacture and value of industry shipments were $2.4 and $5.5 billion respectively.

Because the other primary timber industry is such a diverse collection of establishments, no distinct overall patterns of growth or decline are evident. Employment has averaged about 90 thousand (McKeever and Jackson 1990: table B-5). The constant-dollar value of shipments has tended to increase slowly over time.

Organization

The other primary timber manufacturing industry, like the timber harvesting and lumber manufacturing industries, is composed of small, single-unit companies. Most of these establishments were operated as single-unit companies, and two-thirds were corporately owned.

Regional Characteristics

Regional characteristics of the other primary timber manufacturing industry, like many of the other primary processors, largely reflects regional timber resource patterns. Since many of the manufactured products are made from hardwoods, much of the industry is located in the North. In 1982, about 40% of all industry characteristics were attributable to establishments located in the North (McKeever and Jackson 1990: table B-6). Southern pines are a favored species group for wood preserving; thus nearly one-third of the other primary timber industry is located in the Southeast and South Central subregions. Most of the remaining establishments are located in the Pacific Southwest subregion.

CHANGES IN THE STRUCTURE OF THE PRIMARY TIMBER PROCESSING INDUSTRIES

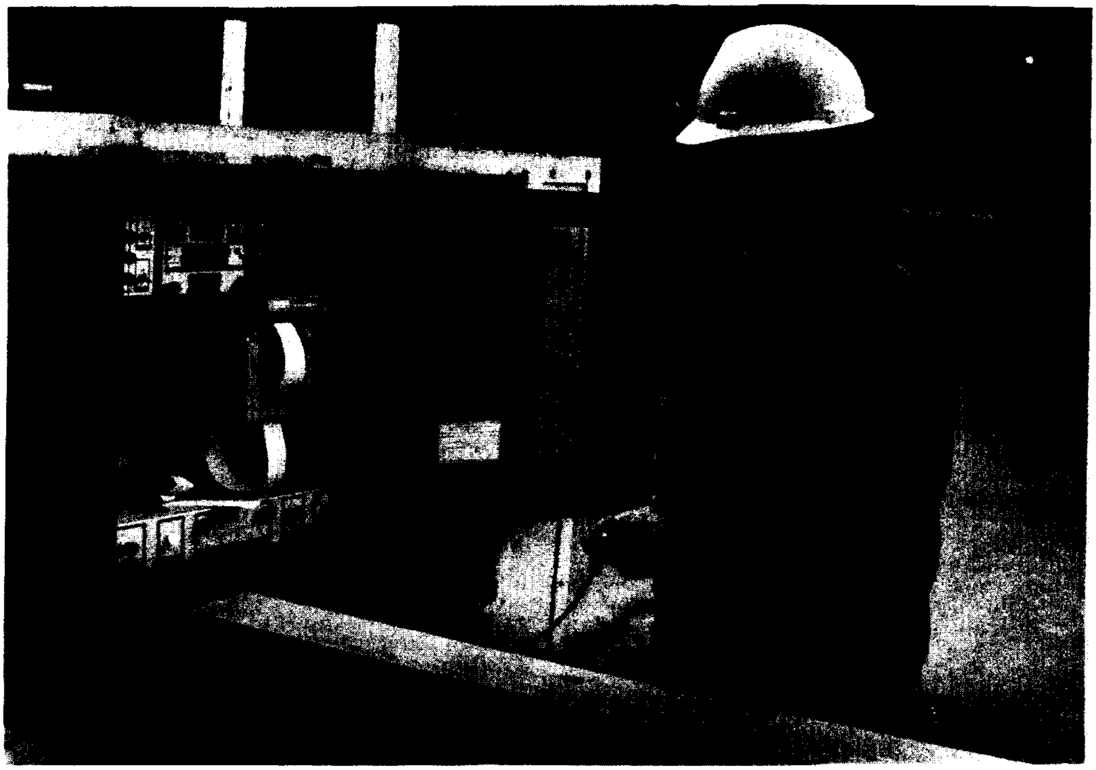
The primary timber processing industries are a dynamic sector of the United States' economy, and are affected by many different socioeconomic factors. These factors include, but are not limited to, changes in population, income, and the demand for forest products. Environmental and human concern factors affect, and are in turn affected by, these industries. Over the last decade, the timber harvesting, and the pulp, paper, and paperboard manufacturing industries have been particularly affected by environmental concerns, while the lumber manufacturing, and structural and nonstructural panels manufacturing industries have been more affected by economic factors. For convenience, the factors affecting timber industries can be classified as economic, physical, or technical. A discussion of each follows.

Economic Factors

Several economic factors have had major impacts on the primary timber processing industries. The economic recession in the early 1980s forced many of the more inefficient solid-wood processors to shut down, some permanently. Some of these closed mills were then sold, refurbished, and reopened under improving economic conditions. Other mills remained in operation, but modernized to improve product recovery and lower operating costs.

High stumpage prices bid during the late 1970s were no longer economic in the 80s when demand for solid-wood products and product prices dropped. This forced many timber harvesters to default on their timber sale contracts. Special legislation was required to prevent the shut-down of many operators in this industry. This has also prompted new rules for bidding on national forest timber.

Competition from Canadian lumber suppliers has taken an increasing share of U.S. softwood lumber markets over the last decade. A coalition of U.S. lumber producers claimed that Canadian producers were unfairly subsidized, and filed a formal complaint with the U.S.



Calibration of a continuous lumber testing machine is an important aspect of overall quality control. This MSR machine separates high strength material for use in engineered wood structures (i.e., trusses, laminated beams).

government. Subsequent negotiations between the United States and Canada resulted in Canada applying, in January 1987, a 15% export tax on certain softwood lumber exports to the United States. This tax may be replaced by appropriate actions in the forestry sector in Canada and such actions may offset all or some of the effects of this tax in British Columbia and Quebec.

Several interrelated phenomena have occurred since the recession in the early 1980s that have affected all of the primary timber processing industries. Long planning horizons, combined with lower rates of return, have made forest products companies more susceptible to takeovers, hostile or otherwise, by other interests. At the same time, greater concentration is occurring within the forest products industries as fewer companies control larger shares of their particular industry.

The last major economic factor has been the expansion of all primary timber processing industries into foreign markets. Increased competition for domestic markets by U.S. and Canadian suppliers has reduced shares for many producers. Traditionally, wood processors have viewed foreign markets as substitutes for domestic markets during poor economic conditions. More recently, this view has been changing and many firms now produce solely for foreign destinations, mostly Pacific Rim countries. The economic recession in the early 1980s forced many companies to seek new markets. These markets have required innovations in mill management and marketing to properly serve these new clients.

Physical Factors

Several changes have occurred in the physical characteristics of the timber resource supplying the primary timber processing industries. Of major concern to producers in the West and the South has been the reduction of available old-growth timber due to harvesting and changes in land classifications. This shift to processing second-growth timber has forced many mills to install new equipment designed for smaller logs. Problems with juvenile wood, quality, and fiber strength found in some second-growth timber have required innovations in processing and have often led to new products and markets. Timber inventories in many regions now contain an increasing share of hardwoods, offering the primary timber processing industries another set of utilization problems and opportunities.

Changes in the physical characteristics of the timber resources have had major effects on the location of the primary timber processing industries. The industry first located processing facilities in the Northeast, then the South, the North Central Region, and the West, always in search of timber. More recently, the industry has expanded processing capacities in the South. The industry has adapted equipment and operating procedures to process the available timber.

Technological Innovations

Changes in the resource have affected the economics of timber production in this country. Many companies now utilize the latest technology designed for smaller diameter logs, fast processing, and high recovery. The combination of changing resources, new technologies, increased competition, and shifts in production locations provide the opportunity for the primary timber processing industries to modernize their mills and improve their markets. The range of technological changes available to the industry in the 1980s will help the industry modernize and develop innovations necessary for the timber processing industry to meet the demands of the future.

CHAPTER 5. INTERNATIONAL TRADE IN FOREST PRODUCTS

The United States has engaged in trade in forest products since colonial times; timber was one of the first natural resources to be exploited and exported from the continent. After three centuries, international trade remains a critical component of the forest sector economy. U.S. producers rely on offshore markets to sell a small but valuable part of their output, while a substantial proportion of U.S. consumption is provided by foreign (especially Canadian) producers. Long-term developments in the U.S. forest sector will be linked inevitably to developments in forest products markets throughout the world. This chapter will present information on trends in U.S. imports and exports of forest products, and will review forest sector conditions in those countries or regions most likely to affect producers and consumers in the United States.

TRENDS IN U.S. TRADE IN FOREST PRODUCTS

National economies have become increasingly interdependent in the post-war period, linked through trade in merchandise and through the flow of capital. The constant-dollar value of U.S. trade in merchandise (imports plus exports) grew at an annual rate of more than 6% between 1950 and 1989. Over this same period, the U.S. economy (the gross national product, GNP) grew at an average (constant-dollar) rate of just over 3%. In 1989, total merchandise trade was 18% of GNP, and net imports were more than 2% of GNP. Trade is an essential part of the U.S. economy, and a source of economic growth throughout the world.

The constant-dollar value of U.S. trade in forest products grew at an annual rate of more than 4% over the period 1950–89 (fig. 40a). In dollar terms, forest products exports grew at a faster rate than all merchandise exports, but in the last decade (1980–89) accounted for roughly 4% of total exports (fig. 40b). In contrast, the forest products component of total imports dropped sharply between 1960 and 1975 (fig. 40b); forest products now account for roughly 4% of total imports.

The United States became a net importer (in terms of total merchandise trade) in the mid-1970s, and the expansion of the trade deficit in the 1980s fueled a continuing economic and political debate. However, for most of this century the United States has been a net importer of forest products. Since 1950 the United States has annually imported, on average, forest products costing approximately 3 billion (1982 $) more than those exported (fig. 40c). This deficit has been extremely volatile since 1970, falling (in absolute terms) to near zero in the recession years of 1975 and 1980, followed, in each case, by equally dramatic increases. In the mid-1980s the forest products trade deficit was unprecedented, approaching $6 billion (1982 $); in spite of this, forest products have accounted for less than 5% of the merchandise trade deficit in this decade. The balance of forest products trade began to improve in the latter part of the 1980s, returning to the long-term average of $3 billion (fig. 40c).

The United States is the world's leading producer and consumer of forest products. The United States is also

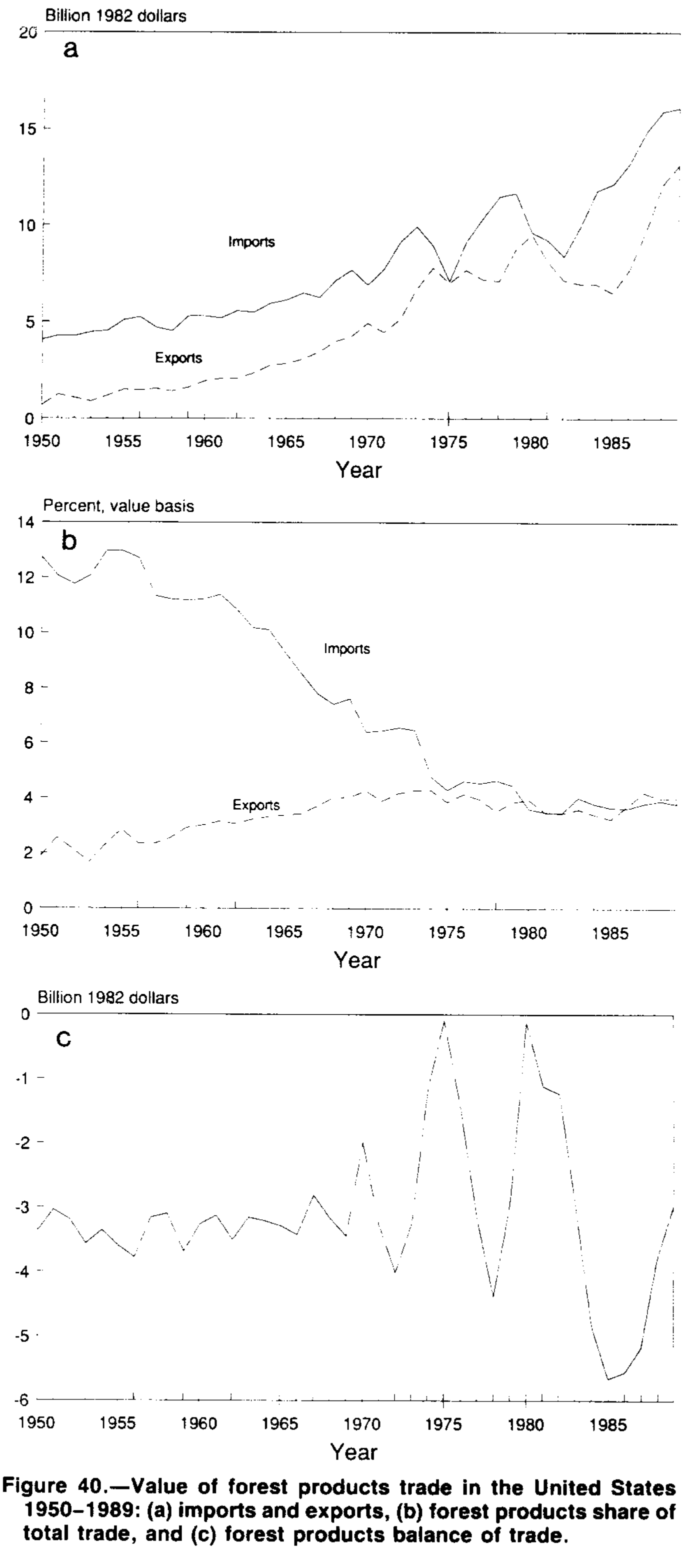


Figure 40.—Value of forest products trade in the United States 1950–1989: (a) imports and exports, (b) forest products share of total trade, and (c) forest products balance of trade.

the world's leading importer of forest products, and is second only to Canada as an exporter of forest products. In 1987 the United States accounted for approximately 16% of world imports of forest products (by value), and over 11% of world exports of forest products. The U.S. share of the volume of world forest products trade was similar. The total volume of U.S. forest products trade in 1987 (7.2 billion cubic feet, roundwood equivalent) was equal to nearly 13% of world production of timber for industrial products.

The volume of imports in 1987 was 4.6 billion cubic feet, roundwood equivalent, a three-fold increase from 1950 (fig. 41a). Imports increased to nearly 30% of U.S. consumption in 1985 (from 15% in 1950), and declined slightly to 28% of consumption in 1987 (fig. 41b). The volume of exports increased even more dramatically over this period, to 2.7 billion cubic feet, from 140 million cubic feet in 1950 (fig. 41a). In 1987, exports were 18% of U.S. production, up from 2% in 1950; in the 1980s the share of production exported remained higher than any other period (fig. 41b). Although forest products exports showed relatively greater gains over the 1950–87 period, net imports were the equivalent of 2 billion cubic feet of roundwood in 1987.

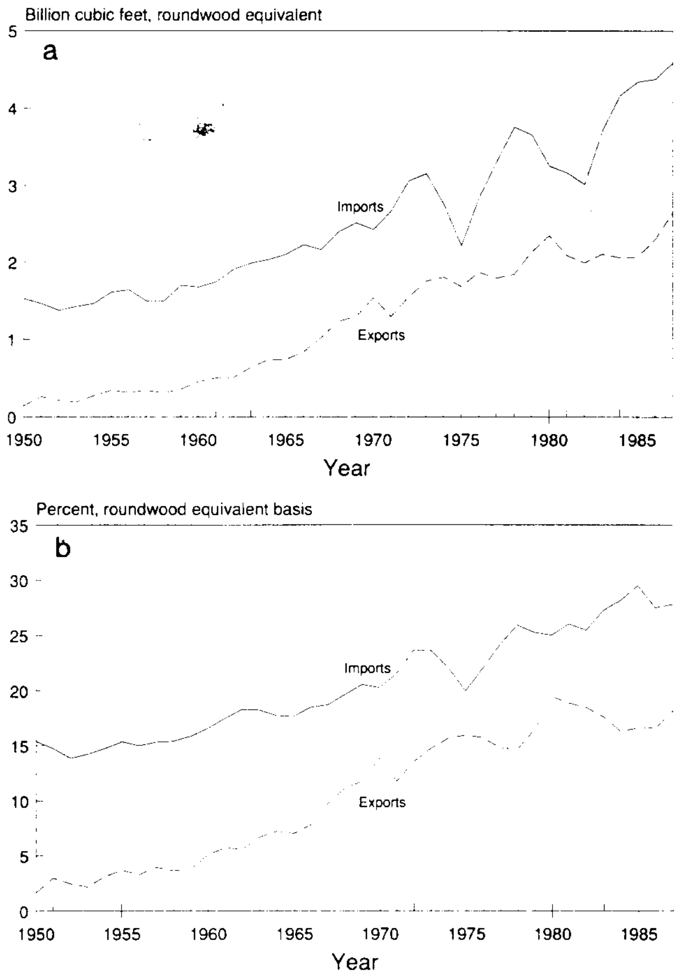


Figure 41.—Volume of forest products trade in the United States 1950–1987: (a) imports and exports and (b) export share of production and import share of consumption.

The general trend in both imports and exports of forest products trade has been upward, but not consistently smooth, especially in the past 20 years—in part as a consequence of business cycles in both the U.S. economy and in the economies of our trading partners. Troughs in the long-term trend of forest products imports coincide almost exactly with troughs in the U.S. business cycle; during the recovery period of the cycle, imports increase at a rate well above the long-term average (see figs. 40a and 41a). In the most recent phase (1982–89), imports increased at nearly 10% per year in constant-dollar terms.

The pattern of U.S. exports of forest products depends primarily on the business cycles of our trading partners, although there are indications of an "export push" during some domestic recessions (see fig. 40a). In the early 1980s, exports declined as a result of a prolonged recession in major markets and a strong U.S. currency. With a more broadly based economic recovery, and following adjustments in the value of the dollar (in 1985), the constant-dollar value of exports has grown at nearly 20% per year (1985–89).

Trends in Imports

The United States spends, in most years, about 50% more on imports of fiber products (pulp, paper, and board products) than on imports of solid-wood products (logs, lumber, panels, and other manufactured products). In 1986, solid-wood product imports were $5.3 billion (1982 $), while fiber product imports amounted to approximately $8.0 billion (1982 $) (table 58). In 1989 the constant-dollar value of solid-wood imports declined to $4.4 billion, but the value of fiber products imports increased to $9.7 billion. The majority of U.S. forest product imports, in both volume and value, originate in Canada. In 1989, Canada accounted for 80% of the value, and well over half of the volume of U.S. forest product imports. However, in the past decade, there have been substantial increases in imports from Western Europe and from Latin America.

More than half (52%) of the 4.6 billion cubic feet (roundwood equivalent) imported in 1987 was lumber; most of the remainder (43% of the total) was in pulp and paper products, primarily woodpulp and newsprint (table 59, fig. 42a). The United States imports relatively small quantities of panel products (plywood, veneer, and reconstituted boards), and an even smaller quantity of logs (all shown as "other" products in fig. 42a).

Imports of pulp and paper products have accounted for 30% to 40% of U.S. consumption, on a volume basis, for more than three decades (fig. 42b). In 1989, pulp products imports accounted for 35% of U.S. consumption, compared to 39% in 1950. The share of U.S. lumber consumption supplied by imports in 1989 was slightly lower than the share for pulp and paper products. However, the 28% market share held by foreign producers in 1989 was more than three times the share in 1950. The decline in the share of domestic markets held by domestic lumber producers contributed to the

Table 58.—Value of United States trade in forest products, 1986.

	Imports	Exports
	Million 1982 dollars	
Solid-wood products		
Logs	11.3	1,224.2
Of which: softwood logs	7.2	1,127.1
Lumber	3,128.2	986.0
Of which: softwood lumber	2,960.2	642.5
Panel products[1]	839.6	298.9
Of which:		
Hardwood plywood	483.5	13.4
Softwood plywood	34.1	131.1
Particleboard	136.3	34.3
Other solid-wood[2]	1,273.6	472.1
Total solid-wood	5,252.7	2,981.1
Fiber products		
Woodpulp	1,598.2	1,659.2
Printing and writing papers	5,292.6	569.1
Of which: newsprint	3,675.0	194.1
Industrial paper and board	961.9	1,919.9
Of which: industrial paperboard	80.7	1,158.6
Other fiber products[3]	131.7	547.5
Total fiber	7,984.4	4,695.7
Total forest products	13,237.1	7,676.8

[1]*Includes veneer, plywood, particleboard, and hardboard.*
[2]*Includes poles and piling, railroad ties, millwork, and other miscellaneous products.*
[3]*Includes pulpwood, chips, waste paper, and miscellaneous products.*
Sources: Ulrich 1989, U.S. International Trade Commission 1987.

Table 59.—U.S. timber product imports by product group, and specified years 1950–87.

Year	Total	Lumber	Veneer and plywood	Pulp products	Logs
		Billion cubic feet, roundwood equivalent			
1950	1.5	0.5	([1])	0.9	([1])
1955	1.6	.6	([1])	1.0	([1])
1960	1.7	.6	0.1	1.0	([1])
1965	2.1	.8	.1	1.2	([1])
1970	2.4	1.0	.2	1.3	([1])
1975	2.2	.9	.2	1.1	([1])
1976	2.8	1.3	.2	1.3	([1])
1977	3.3	1.7	.2	1.4	([1])
1978	3.8	1.9	.2	1.6	([1])
1979	3.7	1.8	.2	1.6	([1])
1980	3.3	1.5	.1	1.6	([1])
1981	3.2	1.5	.1	1.5	([1])
1982	3.0	1.5	.1	1.4	([1])
1983	3.7	1.9	.2	1.6	([1])
1984	4.2	2.1	.1	1.9	([1])
1985	4.3	2.3	.2	1.8	([1])
1986	4.4	2.3	.2	1.9	([1])
1987	4.6	2.4	.2	2.0	([1])

[1]*Less than 50 million cubic feet.*
Note: Data may not add to total because of rounding.
Source: Ulrich 1989.

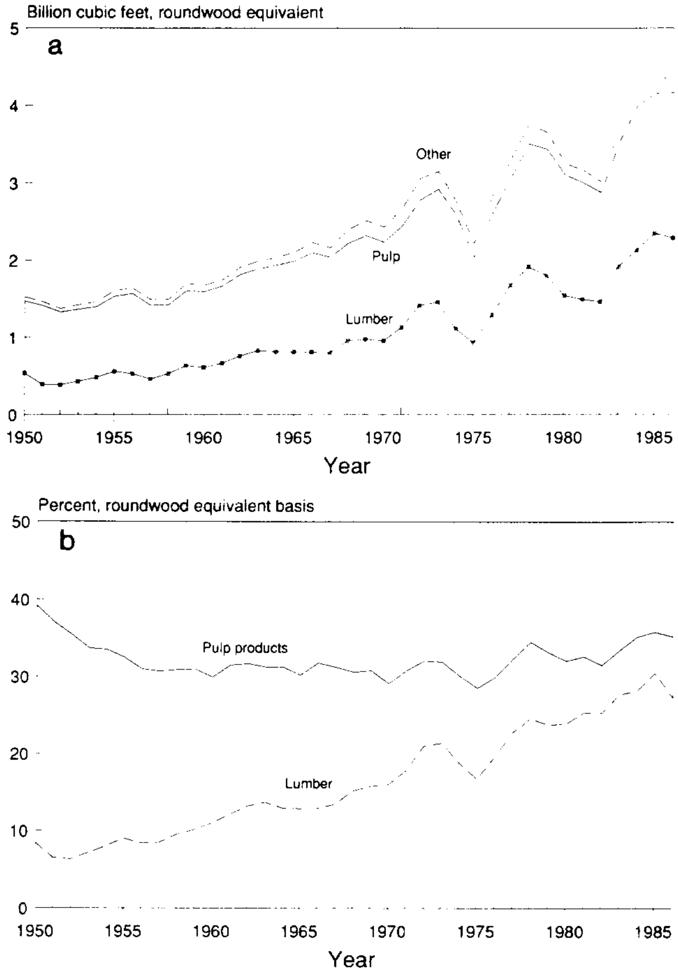


Figure 42.—Forest products imports 1950–1986: (a) volume of imports by commodity group and (b) share of consumption imported.

increased attention focused on lumber imports in the 1980s.

Lumber

Lumber is the primary solid-wood product import, and accounts for roughly half the volume, and 25% of the value of all forest product imports. In 1989 U.S. lumber imports were more than 2 billion cubic feet, roundwood equivalent (14 billion board feet), more than four times the volume imported in 1950. Most imported lumber is softwood, and over 90% of these shipments originate in Canada. Imported softwood lumber now accounts for nearly 29% of U.S. consumption (fig. 42b). The increase, since 1970, in the share of domestic softwood lumber markets held by imports resulted in strong pressure on the federal government for the protection of domestic producers. In late 1986 as a result of a finding of unfair trading practices, the United States imposed a countervailing duty on Canadian softwood lumber. This duty was subsequently removed, and replaced by fees collected in Canada. This process briefly disrupted lumber markets in 1986–87, and lead to a modest reduction in the share of U.S. lumber consumption that is imported (from a peak of 33% in 1985).

Hardwood lumber accounted for only 2% of the volume, but approximately 10% of the value of lumber imported in 1986. Latin America, Canada, and Asia are the primary sources of hardwood lumber imports. Imports of tropical species account for roughly two-thirds of hardwood lumber imports.

Pulp and Paper

The roundwood equivalent volume of imports of pulp and paper products more than doubled between 1950 and 1987. In 1987 the United States imported fiber products (and raw material) amounting to 2.0 billion cubic feet, roundwood equivalent, compared to 0.9 billion cubic feet in 1950. Imports of pulp and paper products are roughly 35% of total U.S. consumption, down only slightly from the level in 1950 (see fig. 42b). Pulp and paper products accounted for less than 45% of the volume, but nearly 70% of the value of all forest products imported in 1989.

Newsprint accounts for the majority of paper and board imports; over 95% of U.S. newsprint imports originate in Canada. Canada is also the primary source of U.S. woodpulp imports, although woodpulp imports from Scandinavia (primarily Sweden) and Latin America (primarily Brazil) have increased over the past decade and now account for roughly 12% of the U.S. total. Woodpulp accounts for 20% of the value of all pulp and paper products imports.

Panel Products

Imports of panel products increased substantially between 1950 and 1987 (from 5 million cubic feet, roundwood equivalent in 1950, to nearly 200 million cubic feet in 1987), but remain a minor component of total imports. Panel products accounted for roughly 5% of the volume, and 7% of the value of forest products imported in 1986. Hardwood veneer and plywood compose the majority of panel imports. Since the mid-1960s the United States has relied on imports for more than half the annual consumption of hardwood panels; in 1986 imports accounted for more than 75% of U.S. consumption.

Most hardwood veneer and plywood imports originate in Asia, primarily in South Korea, Taiwan, the Philippines, and Japan. The implementation of log export restrictions, imposed by Southeast Asian timber producers (Indonesia, Malaysia, and the Philippines) has shifted processing, and shares of the U.S. market to these countries, and away from the traditional Southeast Asian suppliers. However, in 1986 Canada supplied roughly 16% of U.S. hardwood veneer and plywood imports, and Latin America (primarily Brazil) and Western Europe (using, for the most part, tropical African logs) combined to supply an additional 10% of the U.S. import total.

Softwood veneer and plywood accounted for less than 1% of total forest product imports in 1986. Imports are also a minor share of U.S. consumption (roughly 1%). Until recently, Canada accounted for most softwood veneer and plywood imports; however, in 1986 Canada was the origin of just over 50% of U.S. imports. Western Europe, Latin America, and Asia (primarily South Korea, Taiwan, and Japan) have all increased their exports of softwood panel products to the United States.

Imports of other panel products, including particleboard, oriented strand board, and wafer board have increased significantly since the mid-1960s. Together these products accounted for nearly 15% of panel product imports in 1986, but as with softwood panels, imports are a relatively minor component of U.S. consumption. Canada supplies most U.S. imports of these products, although Latin America (primarily Mexico) now contributes 10% of U.S. imports.

Other Products

In addition to these commodities, the United States also imports a wide variety of miscellaneous solid-wood and fiber products. Other solid-wood imports include a small quantity of logs, posts and poles, fuelwood and charcoal, wooden containers, and miscellaneous manufactured products. Imports of these products in 1986 totaled more than 1.2 billion dollars. The majority of these imports originated in Canada (over 95%); Mexico accounted for roughly 2% of the total value of U.S. imports of miscellaneous solid-wood products. Miscellaneous fiber products imports include wallpaper, albums, books, and other printed material.

Trends in Exports

As is the case with imports, export trade in pulp and paper products is more valuable than solid-wood products. In most years, the value of exports of fiber products exceeds the value of solid-wood products by roughly 50%. On a volume basis, trade in the two commodity groups is nearly equal. In 1986, fiber products (pulp and paper) accounted for more than 60% of the value, and 50% of the total volume of forest products exported by the United States (tables 58 and 60, fig. 43a). Although fiber products account for nearly all the growth in imports between 1982 and 1989, the doubling of exports between 1985 and 1989 is a result of expansion in both solid-wood and fiber products shipments.

The total volume of forest products exported is nearly 17% of U.S. production, and exports are again approaching the level reached in 1980 (fig. 43b). The total value of forest products exports in 1986 was nearly $8 billion (table 58), but in each of the last 3 years (1987–89) exports (in constant-dollar terms) set a new record. Japan and Western Europe are the primary markets for U.S. forest products, accounting for 30% and 20% (respectively) of U.S. exports in 1986. Latin American and Asian countries (other than Japan) combined to purchase

Table 60.—U.S. timber product exports by product group, and specified years 1950–87.

Year	Total	Lumber	Veneer and plywood	Pulp products[1]	Logs
	Billion cubic feet, roundwood equivalent				
1950	0.1	0.1	(²)	0.1	(²)
1955	.3	.1	(²)	.2	(²)
1960	.5	.1	(²)	.3	(²)
1965	.7	.1	(²)	.4	.2
1970	1.5	.2	(²)	.9	.5
1975	1.7	.2	.1	.9	.5
1976	1.9	.3	.1	1.0	.6
1977	1.8	.3	(²)	1.0	.5
1978	1.8	.3	(²)	.9	.6
1979	2.1	.3	(²)	1.1	.7
1980	2.4	.4	(²)	1.3	.6
1981	2.1	.4	.1	1.2	.4
1982	2.0	.3	.1	1.1	.6
1983	2.1	.4	.1	1.1	.6
1984	2.1	.3	(²)	1.1	.6
1985	2.1	.3	(²)	1.1	.7
1986	2.3	.4	.1	1.2	.6
1987	2.7	.5	.1	1.4	.7

[1]*Includes pulpwood, wood chips, and the pulpwood equivalent of products.*
[2]*Less than 50 million cubic feet.*
Note: Data may not add to total because of rounding.
Source: Ulrich 1989.

roughly 30% of U.S. exports; Canada accounts for more than 10% (by value) of U.S exports of forest products.

Logs

Logs account for more than 25% of the volume, and roughly 17% of the value of U.S. forest products exports. Over 95% of these shipments are softwood logs, 60% of which go to Japan. The People's Republic of China, a customer since 1980, purchased more than 15% of U.S. softwood log exports in 1986, but less than 10% of exports in 1989. Other Asian countries (primarily South Korea and Taiwan) purchase roughly 10% of U.S. softwood log exports. Exports of softwood logs from the west coast to Pacific Basin countries comprise 90% of total U.S. log exports. Roughly 20% of roundwood production in the Northwest, and 7% of total U.S. roundwood production is exported as logs.

Exports of raw material, especially from the high-value end of the quality range (as is the case with both softwood and hardwood logs) have led to controversy. The volume of softwood log exports was minor prior to the early 1960s but expanded rapidly in the 1960s and 1970s, reaching a first peak in 1968, and a higher peak in 1979. Public debate over log exports policy, focused in the Pacific Northwest, has followed a similar cycle. Opponents of log exports, arguing that restricted exports would support domestic employment and reduce domestic raw material prices, were successful in placing restrictions (in 1968), and finally a ban (in 1973) on exports of logs harvested from federal lands west of the

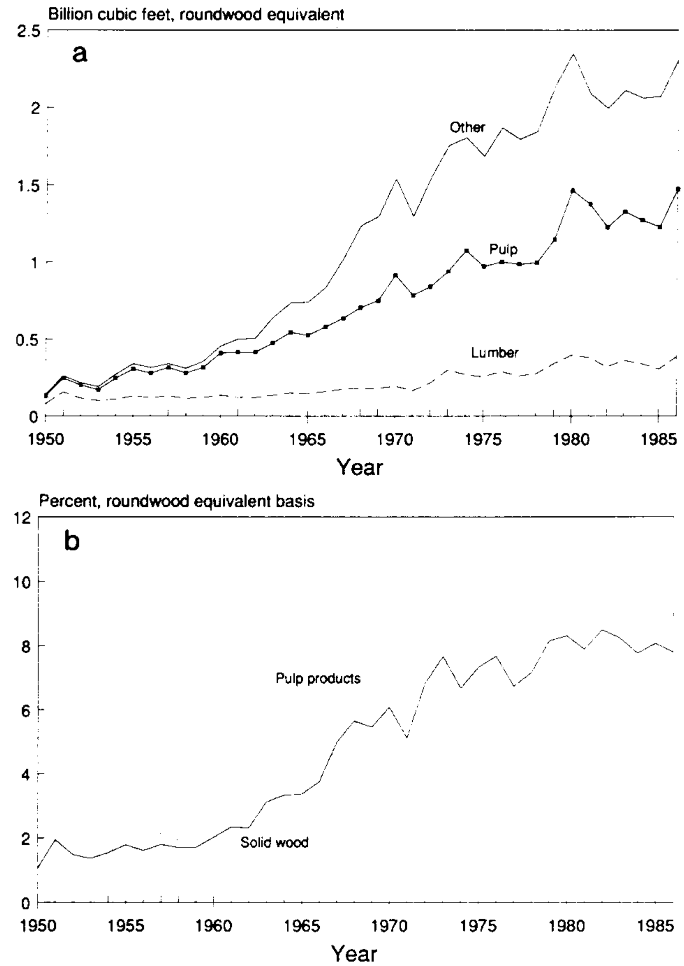


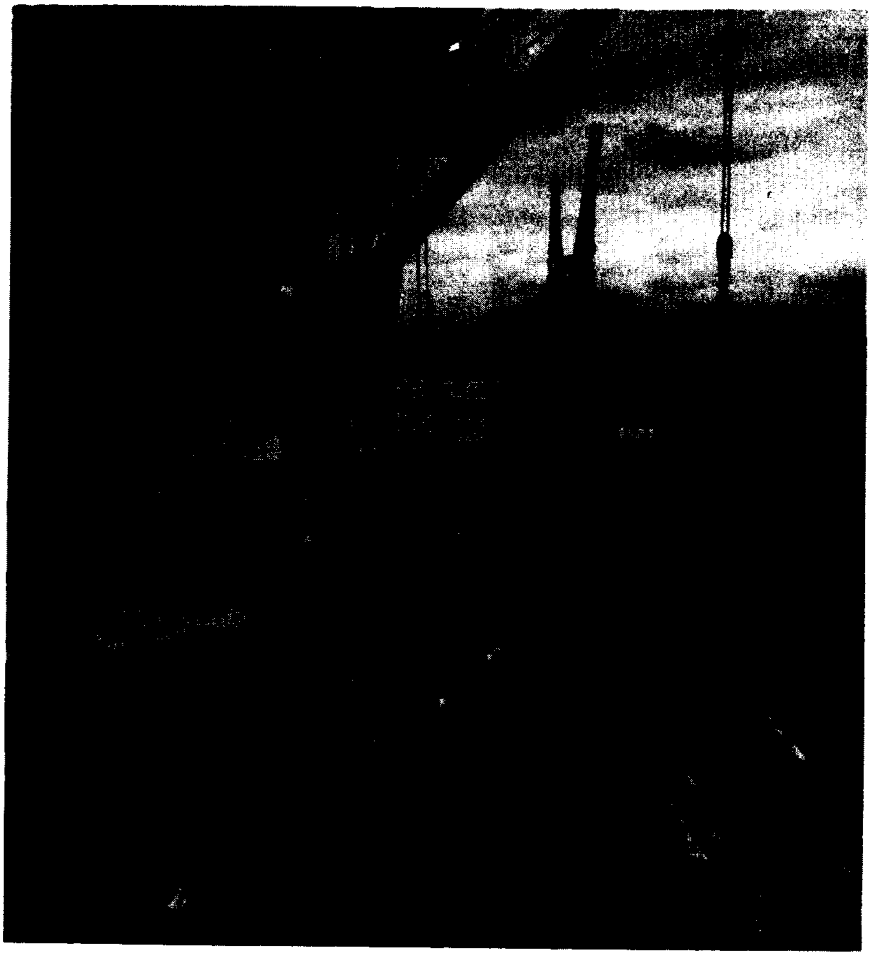
Figure 43.—Forest products exports 1950–1986: (a) volume of exports by commodity group (other includes logs, chips and panels) and (b) share of production exported.

100th meridian. Softwood logs currently exported from the Pacific Northwest are harvested from private land (predominantly forest industry) and from land managed by the states of Washington and Oregon.

Both the volume and total value of hardwood log exports are quite small in comparison to softwood logs. However, hardwood logs are, on average, two or three times the unit value of softwood logs. Although volumes are small in absolute terms, hardwood log exports also have significant impacts in regional stumpage markets. Most hardwood logs exported originate in the North (most of which are shipped to Canada), or in the South (most of which are shipped to Western Europe). In the past 10 years, however, shipments of hardwood logs to Canada have declined while shipments to Asia (including Japan) through west coast ports have increased.

Lumber

In 1986, U.S. lumber exports totaled 385 million cubic feet, roundwood equivalent (2.4 billion board feet). This is nearly four times the volume exported in 1950. Lumber exports in 1986 were valued at nearly 1 billion



Logs being loaded ror export to Pacific Rim countries.

dollars. Softwood species accounted for more than 75% of the volume (1.9 billion board feet) and 65% of the value of lumber exports in 1986. By 1989 softwood lumber exports increased to 3.4 billion board feet, an all-time high.

Japan is the largest market for U.S. exports of softwood lumber, purchasing 43% of the volume. Canada is the next largest market, although softwood lumber exports to Canada in 1986 (400 million board feet) were dwarfed by imports from Canada (14.1 billion board feet). Other major markets for U.S. softwood lumber are the European Economic Community (EEC) (especially Italy, the United Kingdom, and West Germany), Latin America (especially Mexico), and Australia. Roughly 70% of U.S. exports originate in western states and are shipped to the Pacific Basin.

In 1986 the United States exported 500 million board feet of hardwood lumber valued at 347 million dollars. This is more than six times the level of exports in 1950. By 1989, hardwood lumber exports increased to $574 million (1982 $). In spite of this growth in exports (most of which has occurred in this decade), hardwood lumber accounts for less than 5% of the value of U.S. forest products exports. Canada, Taiwan, Japan, and the EEC are the major markets for hardwood lumber.

Panel Products

Exports of panel products in 1986 were nearly 70 million cubic feet, roundwood equivalent. Softwood plywood accounts for roughly 80% of the volume, and just over 50% of the value of panel product exports. Softwood plywood exports increased sharply between 1986 and 1989, nearly tripling. Exports in 1989 were roughly 7% of U.S. softwood plywood production. The EEC is the primary market for U.S. softwood plywood exports; 70% of U.S exports go to these countries. A restrictive quota (with tariffs levied on quantities above the quota volume) limits U.S.-EEC trade in softwood plywood, and exporters in the United States and Canada compete vigorously for this market.

Europe is also the primary market for U.S. exports of hardwood plywood and veneer; more than half of the 13 billion cubic feet, roundwood equivalent (1 billion square feet) exported in 1986 went to the EEC, with a small quantity shipped to other Western European countries. However, European consumption of U.S. hardwood panels in 1986 was less than one-third the quantity consumed in 1978, and this decline accounted for the sharp reduction in U.S. total exports of hardwood veneer and plywood. Exports in 1986 were roughly half the volume exported in 1978. Canada purchases 15% of U.S. exports, and Asian countries (notably Taiwan, South Korea, and Japan) account for 17% of U.S. exports. Hardwood plywood and veneer exports to Asia in 1986 were six times greater than in 1978; growth in domestic economies, and the development of furniture manufacturing (for export) account for much of this increase.

The United States also exports a small quantity of other panel products (particleboard, fiberboard, oriented strand board, and wafer board). In 1986, 171 million square feet valued at 34 million dollars was exported, the highest volume to date. Asian countries (as a group) and Canada each consume roughly 40% of U.S. exports; 15% of the total volume was shipped to Latin America.

Pulp and Paper Products

Exports of pulp and paper products (including pulpwood chips) totaled 1.2 billion cubic feet, roundwood equivalent in 1986. This is nearly 25% of U.S. production, and over half of the volume of all forest product exports. Pulp and paper product exports in 1986 were valued at 4.5 billion dollars, roughly 60% of the value of all forest product exports. As was the case with exports of solid-wood products, exports of fiber products increased sharply after 1985, and in 1989 were at record levels.

Woodpulp accounts for half the quantity, and 40% of the value of pulp and paper exports. The European Economic Community (40%), Japan (20%), other Asian countries (16%), and Latin America (11%) are the major markets for U.S. woodpulp. Shipments to Canada have increased sharply since 1978, and now account for 6% of U.S. exports. Over 60% of U.S. woodpulp exports originate in the South (most of which are shipped to the EEC); most of the remainder are shipped from western states.

Exports of industrial packaging paper and paperboard were valued at 1.2 billion dollars in 1986 (28% of all fiber product exports). Kraft linerboard is the dominant product in this group, and is shipped to markets in Asia, Latin America, Europe, and Canada. Exports of other papers (newsprint, and printing and writing papers) were valued at 570 million dollars in 1986. Asia, Latin America, and Canada are the primary markets for U.S. paper exports. Exports of other paper and paperboard products were valued at 750 million dollars in 1986.

Exports of pulpwood chips were 150 million cubic feet, roundwood equivalent (2.4 million tons) in 1986, down from 280 million cubic feet in 1979. Exports in 1986 were valued at 170 million dollars. Most of the decline in chip exports was in shipments to Japan, the primary market for pulpwood chips. Exports to Japan in 1986 were down nearly 50% from the quantity exported in 1979; however, shipments of woodpulp to Japan doubled over the same period (949 thousand tons in 1986, compared to 557 thousand tons in 1979). Chip exports to Scandinavia also dropped sharply between 1981 and 1986, but here, too, the decline was offset by a modest increase in woodpulp exports.

Trends in Net Trade in Forest Products

Although well endowed with forest resources, the United States has been a net importer of forest products for most of this century. Imports exceed exports, whether expressed in terms of value, or expressed on a common volume basis. The total forest products trade deficit peaked (in absolute terms) in 1985 at nearly 5.6 billion dollars. In most years more than half of the deficit is attributable to trade in fiber products, but in recent years the deficit (in terms of value) in solid-wood products has shrunk to zero. In 1986, trade surpluses with Asia (2.2 billion dollars, most of which was accounted for by Japan), the EEC (900 million dollars), and Latin America (500 million dollars) were overwhelmed by deficits in forest products trade with Canada (8.6 billion dollars) and Scandinavia (550 million dollars). In 1989, the forest products trade surplus with Japan was $3.7 billion (1982 $), and the deficit with Canada was $10.1 billion (1982 $). Stronger demand overseas, combined with a weaker dollar, reduced the overall forest products trade deficit to $2.4 billion (1982 $) in 1989.

The United States is a net importer (on a volume basis) of all major forest product groups except logs (compare tables 59 and 60). Total net imports in 1987 were 2.0 billion cubic feet, roundwood equivalent, and were equal to 13% of U.S. consumption. Net imports in 1987 were down only slightly from the record level in 1985 (2.2 billion cubic feet, and 15% of consumption. Over the period 1980–87 net imports more than doubled, although net imports in 1987 were only slightly higher than those in 1979.

Softwood lumber and newsprint account for the majority of net imports (on a volume basis). In 1986 the trade deficit for these products in terms of value was 5.6 billion dollars, 60% of which is attributable to newsprint. The United States is also a net importer of panel products—net exports of softwood plywood being offset by net imports of hardwood plywood and particleboard. The deficit in panel trade was roughly 600 million dollars in 1986.

The United States was a net exporter of both softwood and hardwood logs in 1986; net receipts for log trade amounted to more than 1.2 billion dollars, most of which is accounted for by softwood log trade. Net exports of logs (600 million cubic feet in 1986) have been 4% to 5% of U.S. roundwood production since 1970. There is also a small (200 million dollar) surplus in hardwood lumber trade. Trade in woodpulp is roughly balanced in both quantity and value; however, the United States imports woodpulp from Canada, and exports woodpulp to Europe, Asia, and Latin America. The United States is a net exporter of industrial papers (roughly 6 million tons for a net gain of 1 billion dollars in 1986).

For more than four decades the United States has relied on other countries to supply as much as 30% of the volume of forest products consumed. However, at the same time, U.S. producers profit from opportunities to trade in foreign markets. The U.S. forest sector is clearly dependent on developments throughout the world.

WORLD FOREST RESOURCES AND TIMBER PRODUCTION

There are approximately 7.3 billion acres of closed forest in the world, roughly 20% of the total land area (table 61). "Closed" forests (those with continuous tree canopies) account for slightly less than two-thirds of the total area classified as forest land. There are substantial, but quite different forests in both the Northern and Southern Hemispheres. In the North, forests are located predominantly in the temperate zone, and coniferous species account for a majority of both the area and volume. Forests in the Southern Hemisphere are predominantly tropical, and composed largely of nonconiferous species. Four countries account for half of the world's closed forests: the Soviet Union, Canada, the United States, and Brazil.

Plantations are an increasingly important component of the world's forests. Although they account for a small proportion (less than 5%) of the total forest area in the world, plantations are important components of the economically viable forest, in terms of timber production, in nearly every region. For example, it has been estimated that more than 30% of industrial timber production in Latin America originated in plantation forests. (McGaughey and Gregerson 1982). Large areas of plantations have also been established for erosion control and for nontimber tree crops (nuts, oils, etc.). The total area of forest plantations in the world in 1975 was estimated at 220 million acres (Sedjo 1987). The rate of plantation establishment increased in the decade following 1975, but slowed in the 1980s. The reduction in the rate of plantation expansion has been the result of: (1) reforestation and afforestation programs nearing either established goals or natural limitations; and (2) economic recession-induced changes in long-term natural resource investment strategies.

Half of the forest plantations of the world are in developed countries in the northern temperate zone (North America, Europe, and the Soviet Union). A massive reforestation effort in the People's Republic of China, begun in the 1950s with the multiple objectives of environmental protection and commodity production, accounts for one-third of the world's forest plantations. Four decades of reforestation in Japan has resulted in the establishment of 27 million acres of plantations of native species. Australia, New Zealand, and Chile have established a total of nearly 7 million acres of exotic coniferous species, most of which are less than 20 years old. The remaining plantations are in developing countries in the tropics, and are composed of fast-growing, predominantly exotic species, both coniferous and nonconiferous.

World forests contained nearly 11 trillion cubic feet of growing stock in 1980; two-thirds of this volume was nonconiferous species, and the remainder was coniferous (table 61). Most of the nonconiferous growing stock (80%)—and half of all of the world's growing stock—is in the tropical forests of Latin America, Asia, and Africa. Over half of the world's growing stock of coniferous timber is in the Soviet Union, although two-thirds of this is in the remote Far East and Siberian regions. The United States and Canada, together, account for 25% of the world's coniferous growing stock, and 6% of the nonconiferous growing stock.

More than half (53%) of the 112 billion cubic feet of world production of timber in 1985 (table 62) was consumed as fuel. In the developing countries of Latin America, Asia, and Africa fuelwood accounts for as much as 90% of total timber removals. In the developed countries fuelwood accounts for roughly one-fourth of the total timber harvest. The United States, the Soviet Union, and Canada accounted for half of world production of industrial roundwood in 1985; the developed

Table 61.—Closed forest area and growing stock volume by species group, by country or region, 1980.

Country or region	Closed forest area	Growing stock: Coniferous	Growing stock: Nonconiferous	Growing stock: Total
	Million acres	*Billion cubic feet*		
United States	482.5	452	258	710
Soviet Union	1,956.0	2,306	728	3,034
Canada	652.6	547	145	692
Europe[1]	209.2	227	180	407
Nordic[2]	119.3	130	25	155
Asia	1,208.4	217	1,254	1,471
Africa	582.8	7	876	883
Latin America	1,826.7	99	3,327	3,426
Oceania[3]	215.8	20	63	83
World	7,275.2	4,005	6,855	10,860

[1]*Except Nordic countries.*
[2]*Finland, Norway, and Sweden.*
[3]*Australia, New Zealand, Papua New Guinea, and Pacific Islands.*
Sources: United Nations 1985, Canadian Forestry Service 1987.

Table 62.—World production of all timber products, and production, net trade, and apparent consumption of industrial timber, by country or region, 1985.

Country or region	All timber products production[1]	Industrial timber products: Production	Net imports	Net exports	Consumption
	Billion cubic feet, roundwood equivalent				
United States	15.9	12.2	2.5	—	14.7
Soviet Union	12.6	9.7	—	1.2	8.5
Canada	6.0	5.8	—	4.6	1.2
Europe[2]	8.6	6.9	3.9	—	10.8
Nordic[3]	3.7	3.4	—	3.1	.3
Asia	34.8	8.7	2.4	—	11.1
Africa	16.2	1.9	.2	—	2.1
Latin America	12.7	3.3	.1	—	3.4
Oceania[4]	1.3	1.0	—	.2	.8
World	111.8	53.0	9.1	9.1	53.0

[1]*Includes timber for industrial products, and fuelwood.*
[2]*Except Nordic countries.*
[3]*Finland, Norway, and Sweden.*
[4]*Australia, New Zealand, and South Pacific islands.*
Source: United Nations 1986b.
Note: Data for the United States differ slightly from those in tables 59 and 60 as a result of varying commodity definitions and conversion factors.

countries, as a whole, accounted for more than 75% of world industrial roundwood production.

One-third of the world's growing stock of timber is coniferous, but in 1985 coniferous species made up 39% of the total timber harvest, and 69% of the harvest of industrial roundwood. In the past two decades the relative importance in world production of temperate zone, coniferous forests has declined only slightly. An increase in the exploitation of tropical hardwood forests—for both fuel and industrial products—and a general stabilization of timber production in North America, Europe, and the Soviet Union has contributed to the modest reduction in world dependence on coniferous timber. However, coniferous forests are expected to remain the primary source of industrial timber for the foreseeable future. It is, in part, a reflection of this preference, that in spite of the fact that more than half of the world's growing stock of timber is in Latin America, Asia, and Africa, these regions produced only one-fourth of world industrial roundwood, and were net importers of industrial wood products in 1985 (table 62).

World timber removals in 1985 were 1% of world growing stock, ranging from a low of 0.4% in the Soviet Union and Latin America, to a high of 2.4% in the nordic countries and Asia. Aggregating across broad regions, timber growth exceeds timber removals; however, shortages of timber exist in a number of local areas. These conditions are most pronounced in the poorest developing countries where the need for food and fuel exceeds the short-run productive potential of the land. Population growth, fuelwood harvesting, and land clearing for agriculture combine to remove existing forests, and inhibit the establishment of new ones. Forest management, with long-term objectives, is foregone. In some developing countries with ample forest resources, the forest represents a stock of wealth that is deliberately liquidated to support both development and consumption.

In developed countries, most of which have a relatively long history of forest management, there are different, but no less significant pressures on forest resources. Atmospheric pollution originating in industrialized areas has had a significant, negative impact on the forests of Central Europe and, to a lesser extent, those in Scandinavia, and North America (Nilsson 1987). Increased mortality, and decreased growth on surviving trees will have both short- and long-run consequences on timber production and timber markets. In the short-run, efforts to salvage dead material may increase timber removals; however, in the long-run both productivity and production are likely to decline if damage is not abated.

WORLD ECONOMIC AND SOCIAL CHANGES AFFECTING FOREST PRODUCTS TRADE

Because wood products consumption and timber trade reflects and is a part of general economic welfare, it is significant that, in the 1980s, world output increased at an average rate of 2.7% per year through 1987; at the same time, world population grew 1.9% per year (International Monetary Fund 1987, World Bank 1987).

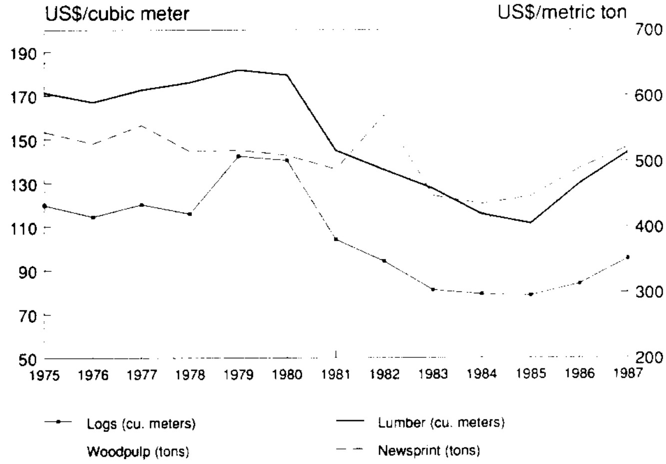


Figure 44.—Indexes of average world prices of wood products 1975–1987.

Thus, output per capita grew during this period despite a major economic recession. Industrial countries, whose consumption drives the bulk of world trade in wood products, increased their output at 7.8% per year on average, while their population grew at about 0.6% per year, indicating not only a growing capacity to buy wood products worldwide, but also a growing disparity between the per capita economic welfare and potential consumption of industrial versus developing countries.

In 1981 and 1982, world economic growth slowed markedly, then recovered in 1983. Trade in wood products reflected that trough, with annual exports of lumber declining 11% between 1979 and 1982 then climbing to record levels in 1985, 3% above the previous record year of 1979. Trade in woodpulp was similar. In 1982, woodpulp exports were 8% below the level in 1979; by 1985, exports were 8% above 1979. Paper exports followed a smoother path upward, declining in 1982 by only 5% relative to 1981, then turning upward toward a level in 1985 which was 14% above 1981 (United Nations 1986b).

Average world prices of wood products declined in the early 1980s and through the middle of the decade, recovering after 1985. Figure 44 shows the inflation-adjusted value of world imports of conifer logs, lumber, pulp, and newsprint. The downward trend in prices has been attributed to reduced housing activities in the industrialized countries for demographic and economic reasons—the latter related to the major recession of the 1980s. That recession carried forward a pattern of increasingly intense economic cycles that began in 1970, following a post-war period of relatively stable economic growth worldwide. In general, forest products prices have fluctuated more than trade volumes.

These worldwide averages obscure the influences of changes of intercountry monetary exchange rates; in fact, part of the increase in prices after 1985 is a result of the weakening of the U.S. dollar. For example, the rapid decline in the value of the dollar relative to the yen in 1985 instantly reduced the prices of existing contracts to be paid by the Japanese; contracts typically specify payment denominated in dollars. A 20% decline in the dollar yielded a 20% price reduction to importers. However, this windfall tended to be reduced in subsequent contracts as sellers negotiated to capture some of the gain. Thus, devaluation ultimately pressed upward the U.S. dollar prices of wood products exported, although not by the percentage amount of the devaluation. Eventually, such dollar price increases influence domestic prices. These market effects of the 1985–87 period of dollar devaluation are difficult to distinguish from the effects of a rising trend in demand associated with increased housing activity in the United States and Japan.

During the 1980s, timber-importing countries continued the staged reductions of tariffs agreed upon during the 1970s during the Tokyo Round of the GATT (General Agreement on Tariffs and Trade) negotiations. Examples of reductions especially pertinent to the United States are Canada's tariffs for panels and some paper items, which ranged from 7.5 to 15% and were reduced to a range of 0 to 9%, contingent on a North American agreement on plywood standards (Radcliffe 1981). The Unites States, too, reduced panel and certain paper tariffs from a range of 2.5–20% to 3–8%. Japan's tariffs, mostly in pulp- and chip-based products, formerly 5 to 12%, were scheduled for gradual reduction to 2 to 10%. Reductions were intended to be completed by 1990.

In the 1980s, several countries moved to make their economies more market oriented. Japan took several steps to free capital flows between that country and others, and expanded the ability of Japanese firms and individuals to invest overseas. In New Zealand, federal timber production and processing was moved into the private sector. China's steps toward developing a market economy have been numerous and substantial; they are described later. In addition, several countries made expatriation of foreigners' export earnings easier.

In supplying countries, trade consciousness appears to have been raised, perhaps because domestic markets were weak during the forepart of the decade. Particularly in the United States, but also in Chile, Brazil, and the Soviet Union among others, increasing efforts were made to understand, adapt to, expand, and influence the product demands and standards of consuming countries.

Compared with other commodities, most wood products are characterized as high in weight and volume relative to their value. To move freely in world trade, wood products must have access to inexpensive transportation. Long-distance materials moving became less costly during the 1980s, over many routes for several reasons. Economies of scale were achieved by using steadily larger and more specialized ships in shipping bulk cargoes such as logs. Rapid increase in the use of standardized 20- and 40-foot-long containers that fit on rail cars and trucks, and easily nest in ships, was a boon for U.S. wood products exporters. Many containers were returning empty to Asian countries that were supplying general merchandise in them to the United States; efforts to utilize the containers during the back-haul led to low shipping rates. Containers became a convenient way to handle orders; product packages (such as bundles of lumber and bales of pulp) can be kept together and intact in transit from producer to purchaser. Standard containers also led to "intermodal" transport systems, in which container-carrying trains meet ships at West Coast ports and move cargo directly across the country, offloading the containers onto trucks at a small number of destinations.

Another transient feature of ocean transport was a world surplus of shipping capacity, bringing ocean-transit costs down substantially. Deregulation of inland transport in North America permitted rail and shipping lines to adjust rates that generally declined on main haul routes from inland to coastal areas, while eliminating or raising costs on tributary routes. It also permitted shippers to negotiate lower rates for larger and more frequent shipments.

During the 1980s, there was a significant shift of timber-based manufacture into new wood products. Especially important to the United States were increased production in Canada of waferboard and increased output, within the United States, of medium-density fiberboard for export. High-speed lathes, forming machines, and dryers have lowered costs and increased the marketability of plywood and other panel products. Major pulp and paper capacity expansion was underway worldwide in the mid-1980s, based largely on new pulping processes combining chemical with thermal and mechanical pulp making. This development permitted greater use of hardwoods in printing and writing paper, particleboard, and other products formerly dominated by softwoods—a trend that has allowed the use of lower cost wood supplies.

In both Europe and North America, there has been an increasing recognition of the nontimber benefits of forests. This has resulted in pressures on both public and private forest owners to adjust management objectives to reduce timber production in favor of noncommodity outputs (recreation, wildlife, water). The United States and Europe already achieve the most intensive production of industrial timber products in the world; efforts to increase nontimber outputs of forests will require even more intensive management for timber production on fewer acres.

Economic development in Asia, Africa, and Latin America will bring greater pressure to bear on the forests of these regions, as well. It isn't clear that the developing countries will follow the resource use pattern of the developed countries; inevitably, however, the process of development has led to increased consumption of industrial timber products. Local and regional opportunities to expand production of timber for industrial products will depend, in part, on the ability to find (and afford) substitutes for wood fuel. The availability of capital, too, will determine whether some countries will remain commodity exporters and product importers. Governments in the developing countries face the considerable challenge of striking a balance between long- and short-run objectives; forests—or the lack of them—will be an important consideration. Continued economic growth in the industrialized countries will stimulate demands for timber products that will result in increased trade among these countries.

THE FOREST PRODUCTS SECTOR IN COMPETITOR AND CUSTOMER COUNTRIES

The widely varying economic factors, inside and beyond the wood products industries, that influence an individual country's commerce with the United States will be described in this section. Discussion will cover nations' changing timber resources, recent trends in their wood products manufacture, use, imports and exports, and their market partners. Each of these countries (or regions) is important to the United States as a market for U.S. producers, a supplier to U.S. consumers, or as both.

Japan

Propelled by a number of economic and social factors favoring growth in material well-being, Japan changed from an impoverished, resource- and energy-poor nation, stripped of its colonial empire at the end of World War II, and arrived 30 years later as one of the major industrial countries of the world. The Japanese economy benefitted from a pre-war legacy of emphasis on industrial development, an increasingly urbanized and literate work force, and a highly protected farm sector that made the country almost independent in food products while occupying a rapidly declining fraction of the work force. With close coordination between government and industry, Japan was aggressive in importing foreign technology and in appraising and penetrating foreign markets in targeted commodity areas. In addition, there has been a national willingness to forego consumption in favor of investment. Japan's rates of personal saving have been among the highest in the world despite relatively low rates of interest earned. Frugality permitted rates of growth and fixed capital formation (expenditures on dwellings, plants, and equipment) of about 15% per year into the 1970s—a rate 10 times that of the United States.

With increased industrialization and interaction with the world economy, a growing sensitivity to international economic cycles occurred. Japan benefitted from the rapid economic growth of industrial countries in the late 1970s, and suffered the subsequent decline into the mid-1980s. Figure 45a traces the annual changes in Japan's gross national product (GNP) in real (inflation-adjusted) terms, from 1975 to 1986. In 1975, capital formation (investment) accounted for one-third of Japan's GNP, roughly twice the proportion allocated to investment in the United States. By 1986, the investment share of GNP in Japan declined to about 28%, while in the United States it rose slightly to about 18%.

Japan's population and GNP per capita indicate the number of consumers, their average economic welfare, and ability to spend. Between 1975 and 1986, Japan's

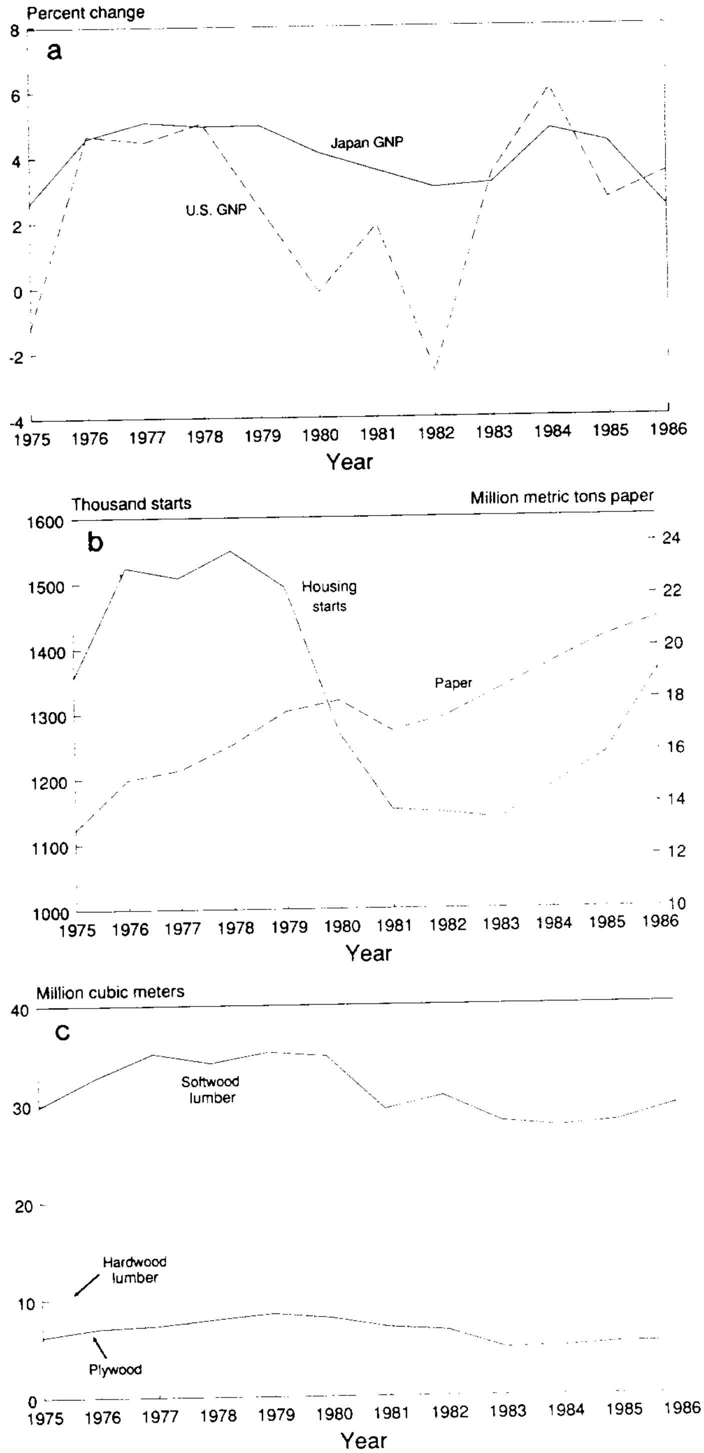


Figure 45.—Japan's demand stimulants for wood products 1975–1986: (a) gross national product compared with the United States, (b) housing trends and paper consumption, and (c) lumber and plywood consumption.

population grew a total of 9%, while per capita GNP grew almost 46%. Comparable figures for the United States were about 12 and 22%; per capita economic welfare in Japan increased almost twice as fast as that in the United States during the decade.

Figure 45b shows the trend of total housing starts in Japan from 1975 to 1986. Housing starts have generally followed economic cycles. The number of housing starts in Japan has rivaled the number in the United States—despite higher land prices, a population only half as large, and relatively high building costs in Japan. From 1977 to 1979, Japanese builders constructed about 1.5 million homes per year, declining to about 1.15 million in 1981. Comparable figures for the United States were 2.0 million and 1.1 million. Wooden houses, as a proportion of the total, declined steadily from about 65% to about 40% of the total. As predicted by Ueda and Darr (1980) at the time of the last Assessment, the average floor space of wooden houses, per structure, increased by about 13%. The trend away from wood houses can be explained by expansion of urban construction, where fire codes discourage the use of wood and land costs encourage high-rise structures that use relatively little structural wood. Rising Japanese affluence and a preference for wood is leading to an increase in the average size of single-family houses.

Wood Products Consumption

Japan is a major consumer of all wood products. In 1985, the Japanese consumed 370 pounds of paper and paperboard and about 10 cubic feet of lumber per capita (United Nations 1986a). Comparable figures for the United States are 625 pounds of paper and 32.2 cubic feet of lumber. The Japanese are especially appreciative of high quality in writing and wrapping papers. The important role of Japanese exports and growing domestic consumption of packaged goods accounts for the large volume of paperboard consumption. Consumption of paper in Japan has increased at an average rate of 2.5 to 3.0% per year; use of container board declined in the 1975–86 period by about 10% (Feng 1987). Although most of Japan's paper is produced domestically, about 20% of the pulp used comes from imports. There are about 600 paper and pulp plants in Japan, of which the top 10 produce about 70% of the paper and 40% of the paperboard manufactured (Nippon Mokuzai Bichiku Kiko 1986). Of the 20 million tons of paper and paperboard consumed in Japan in 1985, 50% was recovered for recycling. This proportion has risen steadily, as it has in the United States, where 26% is recovered (Kawake 1987). Figure 45b shows the trend of total consumption of paper and paperboard.

Figure 45c shows consumption of hardwood lumber, softwood lumber, and plywood. The decline of wood consumption in the early 1980s (most pronounced for softwood lumber) can be attributed in part to the general economic cycle, and in part to the previously mentioned fall in the proportion of wood-based houses. In addition, Nomura (1986) has cited a 50% decline in the number of new households between 1969 and 1982, and an excess supply of dwellings relative to the total number of households. In any case, the pattern of housing starts changed in mid-1986, driven at least partly by government efforts to stimulate the economy. By mid-1987, total housing starts reached an annual rate of 1.8 million.

With encouragement from U.S. trade associations, Japanese builders have experimented with platform frame construction, a departure from traditional building practices. It has been estimated that 300 to 400 basic sizes of lumber are used in Japan, with hundreds of local variations (Baskerville 1986). In addition, a variety of lumber grading systems are in use. Briggs and Dickens (1984) have estimated that only about 1% of Japan's lumber imports from North America fit Japanese size and grade standards. Although platform type housing is still at a low level (perhaps 3% of Japanese housing starts), the number is growing rapidly. With many of the structural members hidden, this North American approach to building lends itself to timber from young forests in Japan and elsewhere.

The Japanese wood products industry underwent major structural changes in the early 1980s. Declining demand, coupled with restrictions on supplies of tropical logs, sharply reduced the number of sawmills and plywood mills between 1977 and 1986. In both industries there were comparable decreases in employment. Between 1980 and 1985, Japanese annual plywood production declined about 20%. The economic recession in the furniture industry, for which much plywood is produced, was also a strong factor in the decline. By mid-1987, plywood production recovered two-thirds of the previous decline. Meanwhile, research in Japan on gluing thin hardwood face veneers to softwood plywood was successful (Japan Lumber Journal 1987), a development potentially favorable for U.S. exports of softwoods and higher grade hardwoods.

Timber Resources

Japan is about the size of California; 70% is mountainous. There has been an active program of afforestation throughout most of this century, with the forest area increasing from 45% to over 60% of the nation's land between 1920 and 1940 (Elchibegoff 1949). Japan depends on domestic forests for about 30% of its total wood consumption (Nippon Mokuzai Bichiku Kiko 1982). Of the 63 million acres of forest, 38 million acres are natural stands. Because of the country's great north-south orientation and large differences in altitude, the forests range from sub-tropical to sub-arctic in character. Of the forest area, 31% is in national forests; 11% is in other public ownership; and companies and individuals own 58%. About one-third of timber harvests come from the national forests; and of the 28 million acres of plantations, 26% are in national forests (Nippon Mokuzai Bichiku Kiko 1985). There are about 800 million cubic meters of growing stock in the country; 80% are in natural forests. Of logs harvested, two-thirds are sawn and one-third are chipped for pulpmills. About two-thirds of the trees harvested are conifers; of these, sawmills receive 80% (Nippon Mokuzai Bichiku Kiko 1986).

Heavy cutting during and soon after World War II led to intensive reforestation, with replanting of the existing cutover area accomplished by 1956. Thereafter, plantation activity emphasized conversion of natural hardwood forests to conifer stands. Plantation area by age class is as follows:

Age	Million acres
0–15 years	9.5
16–30	10.8
31–40	1.5
41–50	1.0
51+	1.0

Intended harvest ages range from 35 to 80 years, depending on the planned end product (Fenton 1984, Nippon Mokuzai Bichiku Kiko 1985). Figure 46a shows the annual volume of saw logs arriving at sawmills from domestic forests. Because most plywood plants are supplied by logs from Southeast Asia, domestic log arrivals at plywood mills are negligible. The decline shown is attributable to reduced harvests in natural forests caused by the recession of the early 1980s and decreasing availability of mature timber. The economic recovery of the mid-1980s did not stimulate increased domestic log production, partly because plantations are not yet able to offset reductions in harvests from natural stands.

Wood Products Trade Patterns

Japan is the United States' largest export customer for wood products; in 1989, forest products exports to Japan were nearly $4 billion (1982 $). Changes in the pattern of Japan's wood products trade in the 1980s have particular significance to American producers. For example, Japanese imports of Canadian softwood logs grew significantly in the early 1980s; in 1986, Japan's log receipts from Canada equaled about 17% of those from the United States. A reduction in Canadian exports (discussed in the section on Canada) would widen American export opportunities. Imports of pulp chips from North America declined in the early 1980s, partly because of Japanese intentions to diversify their sources (Schreuder and Anderson 1987). Of a total of 6 million tons of chips imported, 34% came from the United States in 1986. The 1980–1986 decline in imports from the United States was 45%, but this was partially offset by an increase in imports of U.S. woodpulp.

Japan's softwood log and lumber imports have moved with economic cycles (fig. 46a). There has been a distinct upward trend in the ratio of lumber to logs. Plywood imports (fig. 46b) have been relatively small in volume and strongly cyclic.

Japanese imports of hardwood logs, used primarily in plywood and furniture manufacture, declined by 43% between 1979 and 1986, to about 450 million cubic feet per year. The change has had two principal effects on the United States. Japan (and other countries) have found that they can substitute hardwood logs from the U.S. Southeast and some from the West Coast, for Southeast Asian logs in some uses. In 1986, Japan imported 1/2 million cubic feet (about 3 million board feet) of hardwood logs from the United States. A second effect is through the substitution of particle and chip-based panels for the cores of furniture pieces that will be covered with paint, paper, plastic, or wood veneer. The United States competes with a number of countries in these expanding Japanese markets.

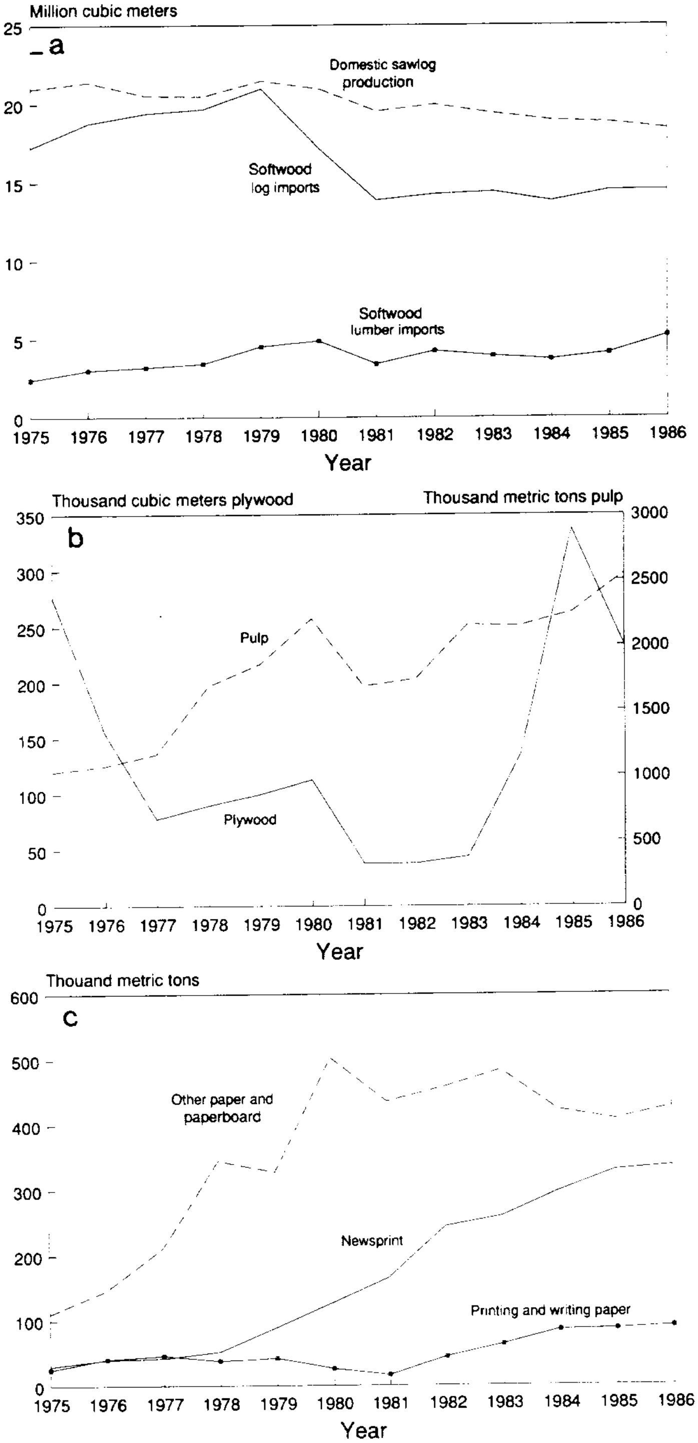


Figure 46.—Japan's domestic and imported timber supplies 1975–1986: (a) sawlogs and lumber, (b) plywood and pulp imports, and (c) paper and paperboard imports.

Japan's capacity to make pulp and paper expanded very little in the 1980s, in spite of steady growth in domestic demand. Chip imports increased to offset reduced availability of sawmill residues; however, most of the increase in consumption was supported through imports of pulp and paper products (fig. 46b and 46c). The United States has been a major supplier of the full array of fiber products in Japanese markets.

Between 1975 and 1980, the value of the yen relative to the U.S. dollar rose by 11%, then declined 21% by 1985, then rose again 32% by mid-1986; all in real (inflation-adjusted) terms. These changes coincided roughly with expansions and contractions of the business cycle, intensifying the cyclic price fluctuations that Japan confronted in dealing with the United States. Although viewed by some as an opportunity to speculate in currency, the Japanese have generally preferred long-term price stability.

For many reasons, including long-term price stability, long-term supply of raw materials, diversified sources of supply, and reducing labor costs, Japan has established joint ventures for processing forest products (and other goods) in many countries. This has been coupled with direct ownership of forest land in some cases. Countries involved include Canada, the Soviet Union, China, Southeast Asia, Oceania, several countries in Latin America, and the United States. In the United States, in particular, Japanese investors see an opportunity to acquire land with secure title, in a relatively stable economic and political environment, and at prices that in the 1980s were low relative to past values and Japanese domestic property costs. By the mid-1980s, Japanese offshore investments were a common feature of the world timber economy.

China

Although China has had hundreds of years of experience in international trade, political and military events of the Twentieth Century produced an insular social structure that discouraged foreign commerce until a major change in federal policies in 1979. Thereafter, brisk commercial interchange with a number of countries, in numerous commodities, occurred. However, the ease of purchasing relative to selling led to a near exhaustion of foreign exchange and downward pressure on the value of the yuan. The foreign exchange difficulty of 1984 and 1985 appears clearly in figure 47a. In 1986 and after, stricter discipline concerning imports, and expansion of exports of general merchandise, largely to Japan (the latter enhanced by Japan's strengthening currency), led to a gradual but steady increase in foreign exchange earnings.

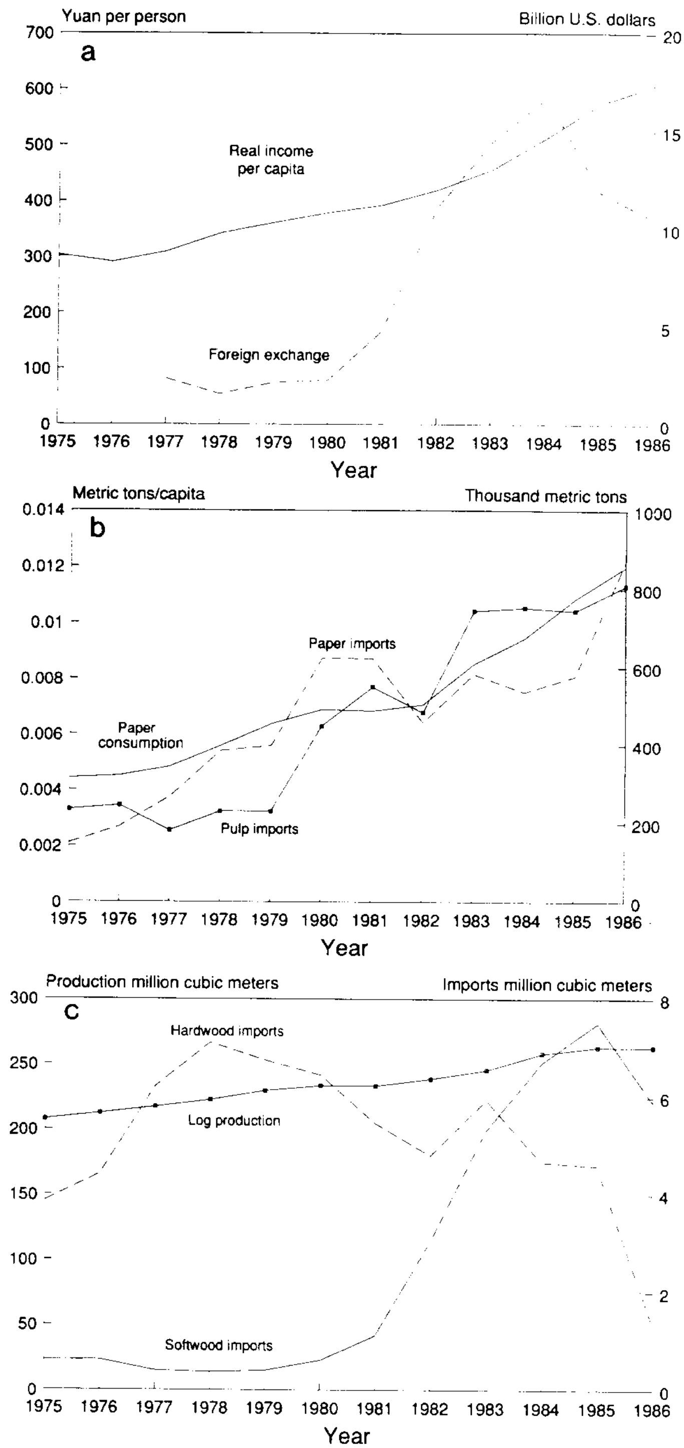


Figure 47.—China's wood products demand 1975–1986: (a) per capita real income and foreign exchange, (b) paper consumption per capita and pulp and paper imports, and (c) log production and imports.

Wood Products Consumption

China's low per capita income, about $300 per year, substantially offsets the market potential suggested by the size of the country's population—about 1.2 billion—5 times that of the United States. However, income averages obscure the somewhat higher incomes in coastal provinces, closer to offshore wood products sources, as well as the emergence of a relatively affluent segment of the population. Although income concentration has not been published, figure 47a shows the recent trend of per capita real income, which has risen sharply. These figures understate the economic welfare of the Chinese, especially in rural areas, where services are bartered and their values are unreported.

As China develops, demand is great for newsprint and other papers used in communication, packaging materials for shipments to both domestic and foreign customers, hardwood plywood, and softwood building materials. Paper consumption per capita is about 15 pounds per year, only 5% of that in Japan. Figure 47b shows the recent trend of Chinese pulp and paper imports and per capita consumption.

Eight times as many houses are built each year in China as in the United States, but wood is used in few parts of the home. Windows, doors, roof beams, and occasionally floors, are typically made of wood; masonry housing uses wood concrete forms. Nonetheless, large volumes of wood are used in construction projects in China, both as lumber and plywood (Lovett and Dean-Lovett 1986). Of plywood produced, 60% goes into furniture and 20% into construction.

Domestic Timber Supplies

In the mid-1980s, China's forests provided almost 90% of China's roundwood consumption (USDA 1987a). However, the proportion of softwoods declined from 70% in 1965 to 60% in 1984. Figure 47c compares log production and timber imports. The largest reforestation program in the world's history increased China's forest land by 50% between 1949 and the mid-1980s. To preserve domestic timber supplies, China has imposed a wood substitution policy requiring that other materials be used in such conventional wood products as trusses, walls, railroad ties, mine props, and firewood. Despite these measures, China's estimated demand for timber other than firewood exceeded the growth of commercial roundwood by about 32% in the mid-1980s (Lovett and Dean-Lovett 1986). In 1985, Chinese consumption of lumber and plywood was about one billion cubic feet—about 20% of U.S. consumption (United Nations 1986a).

Wood Products Trade

Figures 47b and 47c show China's imports of pulp, paper, softwood logs, and hardwood logs in recent years. Pulp and paper imports have moved upward steadily, while log imports have responded to foreign exchange availability. Hardwood log imports have been affected strongly by supply constraints in Southeast Asia. China is one of the world's largest importers of solid-wood products (primarily softwood logs); the United States is the majority supplier, accounting for about 65% of Chinese imports. The Soviet Union and Canada supply, respectively, roughly 25% and 5% of Chinese imports. In paper and paperboard (excluding newsprint), the United States furnishes about one-third of China's imports. Most of the rest comes from Japan. Chinese tariffs are relatively high, ranging from 13% for softwood logs to 50% for finished softwood lumber and up to 100% for finished items such as window frames (including a 10% "product tax" on imported items). China's stated preference for logs over finished goods (e.g., Leland 1986) is attributed to conservation of foreign exchange and support of activity at China's 20,000 sawmills (Lovett and Dean-Lovett 1986). This objective is demonstrated plainly by the tariff schedule. In any case, in 1986, China accounted for about 18% of U. S softwood log exports; while softwood lumber and plywood percentages were nil.

South Korea

South Korea vies with China for third place, after Canada and Japan, in U.S. forest products trade. Most of that trade involves South Korea's imports of U.S. softwood logs. South Korea has also been one of several nations manufacturing hardwood plywood and furniture for export to the United States and elsewhere.

Domestic Markets

Although burdened with a significant fraction of the world's intercountry debt, South Korea's economic role has been enhanced by a rapid rate of economic growth as seen in figure 48a. GNP has regularly grown three to four times as fast as in the United States. The trend of individual economic welfare (per capita real income) in South Korea parallels that of Japan, although South Korea remains several years behind, and was impeded by the recession of the early 1980s.

South Korea's population is 34% that of Japan, but consumption of wood products is about 10% of Japanese wood use. This reflects lower per capita income and a different structure of wood-dependent economic sectors. Like China, South Korea's use of paper products is growing rapidly, including heavy demand for packaging materials for exported products. Also like China, South Korea uses little wood in residential construction and relies on reinforced concrete and other masonry products. Thus, solid-wood primarily goes into doors and window frames and interior decoration. The greatest use of softwoods is in construction, including concrete forms and scaffolding. South Korea makes extensive use of mine props in the production of coal. With Japan and Taiwan, South Korea has been a significant producer and user of hardwood plywood, primarily for export furniture production. Restraints on hardwood log exports in several Southeast Asian countries in the early 1980s sharply reduced plywood manufacture in South Korea. Furniture plants turned to imported plywood from countries formerly exporting logs, and to reconstituted wood panels from a number of countries. By the mid-1980s, half of South Korea's plywood capacity was idle (Schreuder et al. 1987).

Domestic Timber Supply

Two-thirds of South Korea is forested, but 90% of the stands are less than 20 years old; only 2% are older than 40 years (Schreuder et al. 1987). However, there has been an energetic reforestation program, and the 20-year trend of the domestic cut has been upward (fig. 48b). The in-

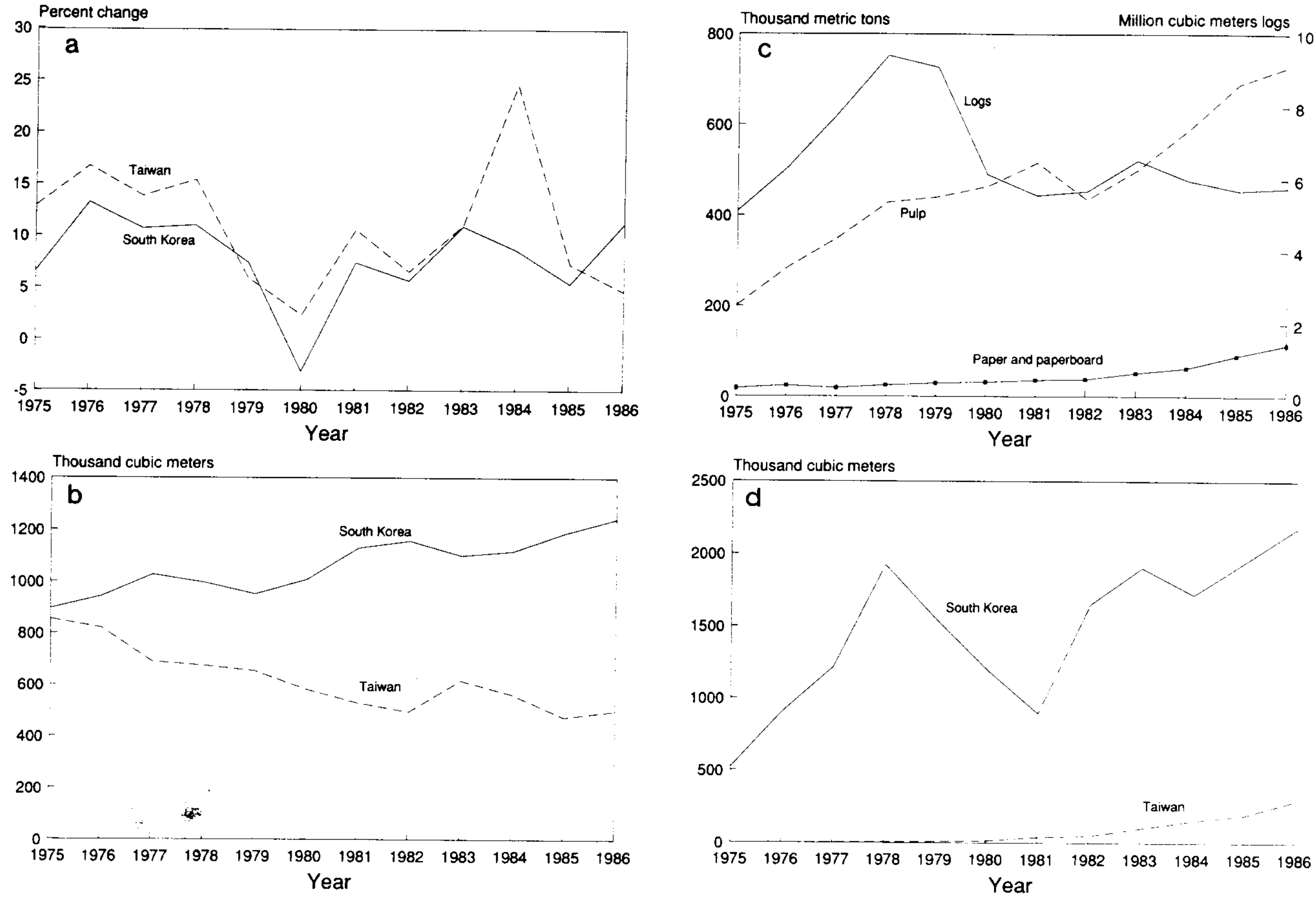


Figure 48.—South Korea's and Taiwan's wood products demand 1975–1986: (a) economic growth rates—annual change in gross domestic product, (b) domestic timber production, (c) South Korean pulp, paper, and log imports, and (d) U.S. hardwood log exports to Taiwan and softwood logs to South Korea.

crease, however, has been outstripped by domestic consumption. By the mid-1980s, harvests provided only about 15% of wood use; almost all of this was softwoods, and the majority was wood of low quality and value.

Wood Products Trade

The decline in South Korean plywood production coincided, in the early 1980s, with a drop in furniture exports, and a reduction in plywood exports to other furniture-producing countries in the Far East. By the mid-1980s, however, furniture production and export recovered rapidly, sustained by the fact that during a period of decline in the value of the U.S. dollar the South Korean won had roughly kept pace. As a result, South Korea could compete effectively with Japanese manufacturers in U.S. markets; in addition, South Korea was able to compete directly in Japanese markets (USDA 1987b).

Figure 48c portrays South Korea's pulp and paper and paperboard imports. In the mid-1980s, the United States accounted for one-third of South Korean pulp imports and two-thirds of South Korea's offshore paper and board purchases.

South Korea accounts for a minor share of U.S. lumber exports. Log exports to South Korea account for about 12% of U.S. offshore log shipments; the United States supplies about 66% of South Korea's softwood log imports. The balance of South Korean imports come primarily from Canada, New Zealand, and Chile. Figure 48d shows that real growth in U.S. log flows to South Korea came after 1975. South Korean orders are especially significant to the U.S. log industry because of South Korea's preference for lower grade logs than are commonly imported by the two other major log customers—Japan and China.

Taiwan and Southeast Asia

American forest products trade with Taiwan and other Southeast Asian countries has been mainly as a customer for hardwood plywood and furniture. Until the 1980s, the pertinent trade flows involved logs moving from the southerly countries into Taiwan, South Korea, and Japan for manufacture and export as higher valued products. By 1980, the Philippines had banned log exports, and export prohibitions were in place in Indonesia and

Peninsular Malaysia. By the mid-1980s, the principal sources of tropical hardwood logs for all markets were Thailand, Sarawak and Sabah in Malaysia, and Papua, New Guinea. These policy changes were accompanied by great expansion of the hardwood plywood industry in Indonesia, with more than 120 plants in operation by 1986 (Schreuder and Vlosky 1986). Major changes in wood product movements within the region have resulted, the most notable being the development of a market for U.S. hardwood lumber and logs. Idle plywood mills in Taiwan (as well as in South Korea and Japan, as mentioned earlier) have led to increases in shipments of temperate hardwood logs. However, U.S. hardwood log exports to Taiwan remain relatively small (fig. 48d).

Flows of wood chips within the region have also changed (Schreuder and Anderson 1987). Shipments from Indonesia have increased as domestic processing of logs has increased. The long-term effect on demand for U.S. chips is unclear, as these changes were taking place during the economic decline of the early 1980s.

The gross national product of the Southeast Asian countries grew at about 5% per year (in constant terms) in the early 1980s. Taiwan's economy expanded at a rate well above the regional average, more than 10% per year (fig. 48a). In spite of relatively strong economic growth, the U.S. dollar equivalent of average per capita income in the regions was only about $600 in 1985 (World Bank 1987). As a result, pulp and paper consumption in Southeast Asia was low in the 1975–1986 period. In addition, a significant amount of regional demand for materials for fiber products was met by local production from nearby materials, including bagasse (United Nations 1986b).

Because of its stronger economy and the ability to satisfy consumption through imports, Taiwan has been able to expand its forest sector while reducing demands on domestic forests. Taiwan's domestic supply of softwoods, for solid as well as fiber products, is in decline (fig. 48b).

The Soviet Union

Relative to other industrialized countries, economic growth in the Soviet Union was modest in the 1980s. It is not surprising, therefore, that per capita consumption of solid-wood products and paper and paperboard products (13 cubic feet and 77 pounds, respectively, in 1985) are well below consumption in the United States and Japan. Nevertheless, Soviet timber resources are vast, and the Soviet Union plays an important role in European and Pacific Rim markets.

The Soviet timber economy has two distinct segments—the area west of central Siberia (here called the "west") and eastern Siberia and the Far East (here termed the "east"). The west is characterized by relatively high population and pressure on declining forest resources. Economic interactions are primarily with European countries. In the east, population is low, forest resources are vast and largely untapped, and orientation of the timber economy is toward exports to Pacific Rim countries.

The West

Twenty-four percent of the country's population lives in the western portion of the Soviet Union (this is also referred to as the European portion of the country). Demands on Soviet forests in the west have been heavy, leading to diminished supplies and a longer reach for domestic timber (Blandon 1983, Braden 1983). The Ural Mountains, a north-south chain about 600 miles east of Moscow, have long been a natural barrier to eastward expansion of the forest industry. However, forests east of the Urals are now being tapped for shipment westward. Estimates of timber supplies remaining in the west range from 50 to 70 times recent harvest levels (Blandon 1983, Braden 1983, Rodgers 1983, Fenton and Maplesden 1986). The portion economically accessible is unknown and difficult to define given the centrally managed economy and the designated wages and prices. Figure 49 shows Soviet shipments of solid-wood products and fiber products (pulpwood, and paper and board) westward, to countries other than those in the Pacific Rim. These products are manufactured from timber harvested in the western forests. In addition to European countries, markets have included Cuba and several Middle Eastern countries. Most of these countries also trade in wood products with the United States.

The East

Declining oil prices after 1978 created significant foreign exchange problems for the Soviet Union because oil had accounted for 80% of the country's export income. During the same period, total Pacific Rim demand for wood products expanded, with the significant demands of South Korea and China more than offsetting relatively static Japanese consumption. Thus, Soviet development efforts in the east were heavily oriented to wood products complexes, supplemented by multipur-

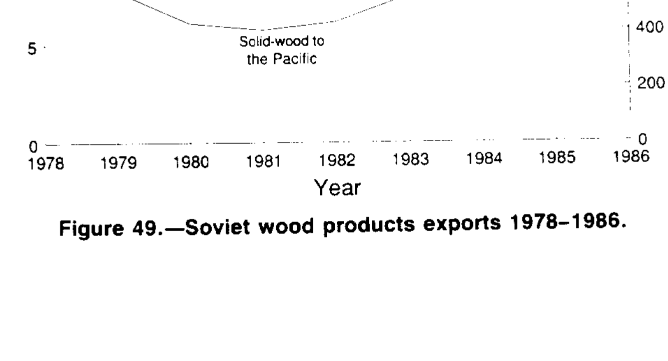


Figure 49.—Soviet wood products exports 1978–1986.

pose expansion of port facilities on the Pacific Coast and a new 2,000-mile railroad from the Pacific to the interior.

Exports from the Soviet east have primarily been softwood chips, pulpwood, logs, and lumber—mostly to China and Japan. Barter and joint ventures are common. Relative to U.S. exports to the Pacific Rim, Soviet shipments are equivalent to about 17% in chips, 52% in pulpwood and logs, and 7% in lumber. Soviet pulp and paper exports to the Pacific are negligible (Fenton and Maplesden 1986). Solid-wood exports to the Pacific region are shown in figure 49.

Soviet development of the east has proceeded throughout this century, primarily for strategic reasons (Mote 1983). Increased forest resource development in the 1980s faces the considerable problems of vast distances, low timber volumes per acre, a sparse transportation network, widely spaced communities, and a severely cold climate. Climatic conditions are comparable to those of far northern British Columbia and the southern part of the Yukon Territory, with timber-growing conditions generally declining as one moves westward from the Pacific Coast. Temperatures get progressively colder in the same direction, with more than three-fourths of the Soviet east having January temperatures lower than those of Fairbanks, Alaska; the 24-hour average temperature in January is about -12°F, and about 60°F in July. Of course, in a geographic zone extending more than 5,000 miles east-west and more than 2,000 miles north-south, with varied topography, there is significant climatic variation. For the same reasons, timber that is sparse on average, has significant concentrations of preferred species in high-quality stands. In expanse the Soviet eastern forest compensates for the severe climate. The Soviet east has about half of the world's softwood timber resource (Blandon 1983, Fenton and Maplesden 1986), and provides about 12% of the solid-wood products moving into Pacific Rim markets (excluding trade between Canada and the United States).

Canada

Merchandise trade between Canada and the United States is the largest bilateral exchange in the world; this is also the case in U.S.-Canadian forest products trade. Canada imports modest quantities of lumber and logs, and significant amounts of pulp and paper from the United States. Americans buy large quantities of Canadian softwood lumber, newsprint, publishing papers, and structural panels. As major participants in world trade, Canada and the United States compete to supply chips, logs, lumber, pulp, and most paper and board products to European and Pacific Rim markets. Major policy changes in the 1980s concerning wood products in particular, and U.S.-Canada trade generally, may materially affect the economics of trade between the two countries.

Canada's Timberland

Summaries of Canada's timber situation (Reed and Associates 1978, Bonnor 1982, Nilsson 1983, Honer and Bickerstaff 1985) indicate that Canada is second only to the Soviet Union in the extent of its total forest land. Although only half is judged suitable for timber production, the "productive" portion is about 10% larger than the comparable area in the United States. Of that area, about 550 million acres, half is in the eastern provinces, a quarter is in British Columbia, and the balance is in the prairie provinces and the northern territories. Only about 8% of the suitable forest land is privately owned.

Comparative aggregate timber inventory data is available for Canada and the United States as of about 1980. At that time, Canada had about 500 billion cubic feet of gross merchantable volume in mature forests (Honer and Bickerstaff 1985). Even after adjustments for decay and other defects, Canada's inventory exceeded the U.S. commercial saw timber volume of about 413 billion cubic feet.

About 80% of Canada's timber inventory is softwood. Hardwood, an increasingly significant part of the resource economically, is about two-fifths of the timber resource in the prairie provinces, one-third in Ontario, one-quarter in Quebec and the Atlantic provinces, and less than 5% in British Columbia and the territories.

Honer and Bickerstaff (1985) estimated that about 55% of Canada's stocked productive forest lands are recently regenerated or immature, with 45% mature or overmature. Some of the mature timber is the product of centuries of natural forest recycling; some is the result of harvesting and regeneration within the past 100 years. The analysts estimated that half of the remaining volume of mature and overmature timber is in British Columbia, with about one-quarter in Quebec and Ontario. Honer and Bickerstaff also estimated that the annual depletion of the growing stock is about 1.3%, of which about one-half is attributable to harvesting and one-half to fire, insects, and disease.

They estimated that, of the depleted area, 8% has been replanted, 72% has regenerated naturally, and 20% has gone out of production. The latter statistic was a matter of great technical and public interest in the early 1980s, leading to a major Federal-Provincial joint venture aimed at forest renewal (Environment Canada 1981, O'Hara 1985, Reed 1986). In connection with this program, over 700,000 acres received forestry treatments, including one-half million acres of site preparation and regeneration in 1985 (Canadian Forestry Service 1987).

Domestic Consumption and Production

Figure 50 compares Canada's per capita gross national product with that of the United States. Per capita real income in Canada increased at about 2% a year between 1975 and 1986, less rapidly than that in the United States, and significantly slower than the developed economies of Asia. Thus, Canadian markets for wood products have expanded less briskly than have those in the Pacific Basin. In forest products, Canada's consumption of all commodities, including wood products, is about one-tenth that of the United States. Between 1975 and 1985, Canada's per capita consumption of paper and paperboard increased 34%, while in Japan consumption increased 44%.

Figure 51 shows log production, including pulpwood, by region between 1975 and 1986. The prairie provinces are included with the interior West. The effect of economic cycles is clearly seen, as is the large role played by the interior West. The trend of lumber production (not shown) is similar. Again, the position of the interior West is significant, as is the increasing participation of the eastern provinces. Plywood production is not displayed because little is involved in trade with the United States. However, waferboard, a product developed in the 1960s and produced commercially since 1976 in Canada, is important. Canadian production of waferboard doubled between 1983 and 1985, and exports to the United States account for 40% of Canadian production (about 70 million cubic feet).

Pulp production grew 40% in Canada between 1975 and 1986. Notable is the Canadian trend toward new pulping processes (chemical-thermal-mechanical pulping), with new plants totaling more than 700,000 tons per year either under construction or planned in the mid-1980s (Young 1987). Newsprint production has been flat, while manufacture of other paper and paperboard doubled over the 11 years.

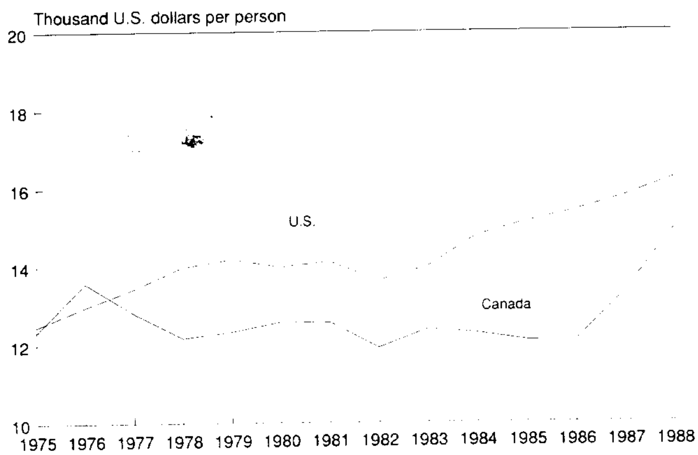


Figure 50.—Per capita real income in Canada and the United States 1975–1988.

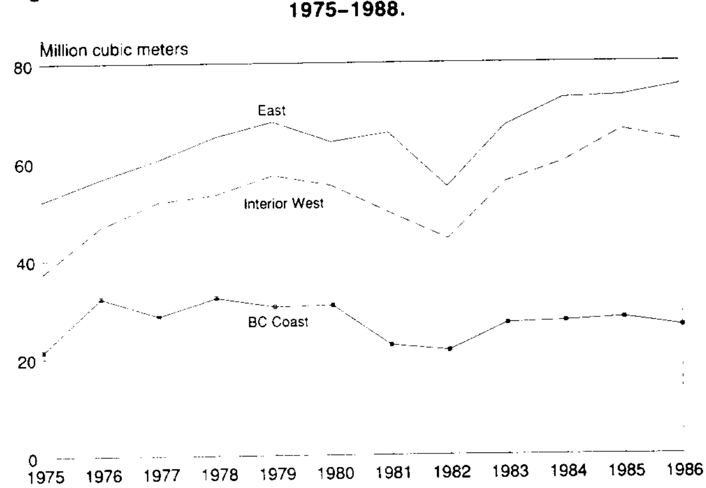


Figure 51.—Canadian log production by region 1975–1986.

Imports and Exports

Like the United States, Canadian imports of forest products from outside North America are limited to veneer and plywood from tropical-hardwood producers, and finished products such as furniture. Relative to other U.S. forest products trade (and U.S. imports from Canada), U.S. forest products exports to Canada have been small. Nevertheless, in 1989 U.S. forest products exports to Canada were roughly $1 billion (1982 $)

Export trade dominates the Canadian forest sector. Figure 52a shows Canadian pulp exports to the world and to the United States. In 1986, the United States accounted for 48% of Canadian pulp exports, with 21% going to the Pacific Rim and most of the balance to Europe. There has been a shift toward hardwood woodpulp in Canada, the result of significant hardwood resources and new pulp and paper technology. In the mid-1980s, there was substantial installation of chemical-thermal-mechanical pulping (CTMP), a change reflected in the character of pulp and paper exports. Between 1980 and 1986, U.S. imports of Canadian paper containing more than 10% mechanical woodpulp increased 70%. During this period, imports of standard newsprint grew 16%.

Canada has long been a major exporter of newsprint, primarily to the United States. Canada accounts for 60% of the world's newsprint exports. As shown in figure 52b, almost 85% of Canadian newsprint exports move southward; newsprint accounts for about 85% of all Canadian paper exports. Canadian exports of other paper and paperboard are shown in figure 52c. More than 70% of Canada's nonnewsprint paper exports go the United States.

Partly because of a long-standing 20% U.S. tariff on softwood plywood, little of that commodity moves between Canada and the United States. A rising trend in shake and shingle shipments from Canada to the United States led to a 1985 complaint by the U.S. industry that U.S. purchases from Canada were increasing at the expense of U.S. production. In 1986, the International Trade Commission imposed a 35% tariff to last 30 months, to be followed by 30 months at 20%, and 6 months at 8%. As a result, U.S. shake and shingle imports declined sharply.

U.S. purchases of Canadian lumber are shown in figure 52d. U.S. imports of Canadian lumber have followed a steady upward trend since 1932, interrupted by peaks and troughs attributable to economic cycles. Between 1975 and 1986, Canadian shipments to U.S. markets tripled, while U.S. lumber production increased about one-third. The U.S. industry appeal for relief, based on the premise that Canada was subsidizing its industry by charging artificially low stumpage prices, failed in 1983 but succeeded in 1986. As a result of negotiations between Canada and the United States, Canada imposed in January 1987 a 15% export fee on exports of certain softwood lumber exports to the United States. This fee may be replaced by forestry-related expenditures in Canada; some polices have been implemented and negotiations between the two countries are continuing.

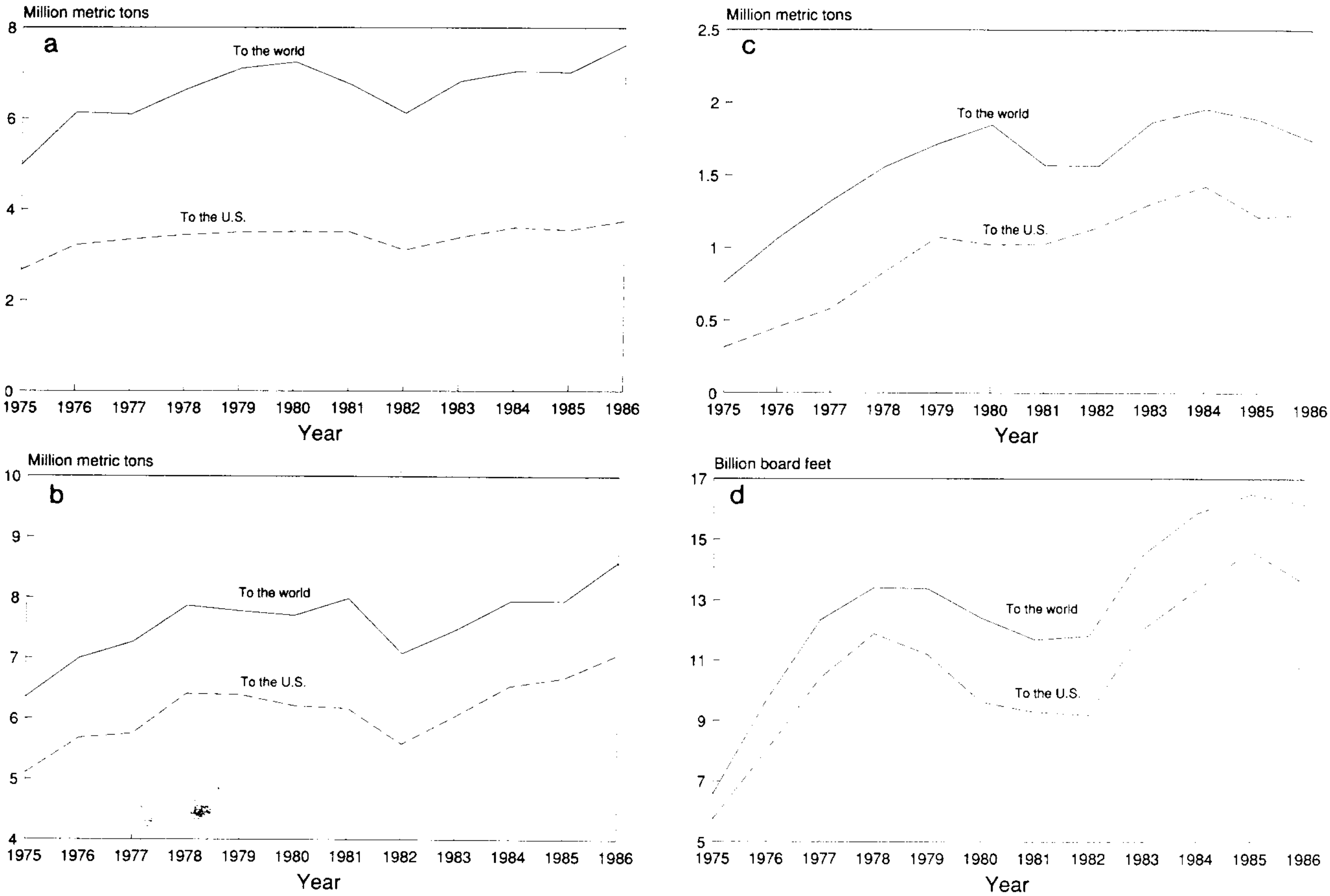


Figure 52.—Canadian wood products exports 1975–1986: (a) pulp, (b) newsprint, (c) all paper and paperboard, and (d) lumber.

Canadian softwood lumber competes with U.S. supplies in markets worldwide; Canada's lumber exports to destinations offshore have been significant for more than a century. Exports beyond North America are shown in figure 52d. In 1986, Canada exported to offshore markets 37% more softwood lumber than did the United States.

Unlike the United States, where tariffs and other trade limitations are federal matters, Canada has delegated control of timber exports to the provinces. British Columbia, the principal source of Canada's log exports, has had a statutory prohibition of roundwood exports from Crown lands since 1906. Provision has been made for exemptions when timber cannot be processed economically in domestic mills, or where timber is surplus to domestic needs. These provisions led to substantial log exports during recent recession years. Exports in 1986 were equal to about 16% of those from the United States, moving to the same countries as were served by U.S. shipments.

Canada's role as competitor in world markets is influenced by the relative values of United States and Canadian currencies. The inflation-adjusted value of the Canadian dollar declined by 14% relative to the U.S. dollar between 1975 and 1985; making Canadian lumber progressively cheaper for American buyers. It has been estimated that the decline accounted for 40% to 50% of the increase in Canada's share of the U.S. softwood lumber market (Flora 1985, Adams et al. 1986). Relative to currencies of other trading partners, Canada's currency declined about 25% from 1976 to 1979, giving Canada a trade advantage that continued into the mid-1980s. As Canada's dollar remained flat in world terms the U.S. dollar rose almost 40% (OECD 1986a, 1986b). After 1985, Canada's currency rebounded, rising in real terms almost 8% relative to the U.S. dollar by late 1987.

The Middle East

Along the eastern shores of the Mediterranean and Aegean Oceans and eastward through India, 18 countries import wood products. Sixteen rely on the United States for part of their supplies. With 25% of the world's population and 5.4% of western nations' economic output, Middle East countries account for 7.5% of world imports of sawn wood and 3.5% of world newsprint imports. Within the region, there are great differences in per capita income. In 1985, in the four lowest-income countries, per capita income was $239, while in the highest four it was $8,947; in the ten mid-income nations, it averaged $957 (World Bank 1987). Imports of sawn wood in cubic feet per capita were .01 for the low-income countries, .76 for the mid-income countries, and 3.32 for the high-income (oil-exporting) countries; a 300-fold differential between high and low. Similarly, newsprint imports per capita were .6, 2.2, and 4.1 pounds in low-, mid-, and high-income countries, respectively, in 1985. Worldwide, average per capita imports of these bench mark commodities were .68 cubic feet of sawn wood and 7 pounds of newsprint.

Faced generally with a dearth of timberland, Middle Eastern countries have emphasized domestic production of fuelwood and charcoal; in none of the countries have imports been a significant source (United Nations 1986b). India is unique in having a large forest area, equal to about 20% of that in the United States (United Nations 1976). However, those forests must support a population three times that of the United States. India has been a negligible importer of wood products except for newsprint, with a minor fraction coming from the United States.

In company with the rest of the world, the Middle East imports only small amounts of plywood. In contrast with much of the world, only small amounts of woodpulp move into this region. Turkey's imports of pulp are notable, however, because they doubled during the early 1980s. Eight countries import some pulp from the United States, accounting for about 4% of U.S. pulp exports. Most Middle East countries import paper from the United States, with particular emphasis on linerboard, which went to 13 countries, accounting for about 9.4% of U.S. linerboard exports.

The region's capacity to expand wood products imports drew attention in the early 1980s despite the relatively flat economic growth of the oil exporting countries. While real economic growth in the United States was about 2.5% per year between 1980 and 1985, the mid- and low-income countries of the Middle East (except for Israel, Syria, and Lebanon) grew at rates between 4 and 6% per year. The United Nations (1986a) noted that between 1970 and 1982 consumption of sawn wood grew more than 10% per year in Egypt, Iraq, Jordan, and Saudi Arabia. During the same period, consumption growth rates for paper and paperboard grew faster than 10% per year in Jordan, Kuwait, and Saudi Arabia. Evidence of the potential for expanding markets emerged in 1986, when Turkey began importing softwood logs, although the shipments also reflected a ban on Turkish timber harvesting (Random Lengths Export 1987).

Europe

Individually, the countries of Europe are more dependent on international trade than is the United States. This is, in part, a function of the fact that no single economy in Europe is as large as that of the United States; it is also a consequence of the fact that the countries of Europe are joined in three major economic and trade alliances. The 12 countries of the European Economic Community (EEC) form the largest group in terms of collective economic power and trade activity.[15] The Nordic countries, along with the nonaligned countries of Western Europe (Austria and Switzerland) form the European Free Trade Association (EFTA).[16] The centrally planned economies of Central and Eastern Europe are members of the Council for Mutual Economic Cooperation (COMECON).[17] The existence of these groupings discourages the imposition of trade barriers (directed at members of the group), and encourages specialization and trade (within the group). It is interesting to note, in passing, that the economic diversity, specialization, and trade dependence of the countries of Europe would be echoed if U.S. trade were to be viewed at the state and regional level.

The importance of trade to the economies of Europe, and the relative importance of Europe in world trade is not simply a product of exchange among members of economic associations. For example, trade between the EEC and nonmember countries is greater than U.S. trade (both imports and exports); members of the EEC ship half of all exports to nonmembers, and nonmembers are the source of half of all EEC imports. This form of trade dependence is even greater for EFTA. The members of COMECON form a more closed group, but one for which external, as well as internal trade is nevertheless important.

Periodic assessments of the current condition and prospective future of European forests are prepared jointly by the United Nations Economic Commission for Europe (ECE) and the Food and Agriculture Organization of the United Nations (FAO). The fourth in this series of studies—a European equivalent to the RPA process—was published in 1986 (ECE/FAO 1986). This review of the situation in Europe relies heavily on the data collected and the analyses prepared in the most recent European timber trends study (ETTS IV).

Forest Products Trade

Producers and consumers of forest products in Europe depend to a far greater extent on trade than do their counterparts in the United States. Forest products imports by all countries in Europe were 8.4 billion cubic feet in 1985 (roundwood equivalent, and including intra-European trade). This was 74% of regional consumption, and 80% of regional production of industrial roundwood. More than 1.4 billion cubic feet (17% of the total volume of imports) originated in countries outside Europe.

The Soviet Union, Canada, and the United States are the primary external sources of European imports. The

[15]*The current members of the EEC are: Belgium, Denmark, France, Germany, Greece, Italy, Luxemburg, Netherlands, Portugal, Spain, and the United Kingdom.*

[16]*Members of EFTA are: Austria, Finland, Iceland, Norway, Sweden, and Switzerland.*

[17]*Members of COMECON are: Albania, Bulgaria, Cuba, Czechoslovakia, the Democratic Republic of Germany, Hungary, Mongolia, Poland, Romania, the Soviet Union, and Vietnam.*

Soviet Union supplies pulpwood, logs, and sawn wood to both Eastern and Western Europe, and accounts for 30% of Europe's external supply. Canada accounts for 25%, and the United States accounts for roughly 20% of the volume of European "external" imports. European imports from North America include sawn wood, wood-based panels, woodpulp, and paper products. Most of the remaining (external) imports came from tropical countries in Africa, Asia, and Latin America. Unprocessed forest products (pulpwood and logs) accounted for more than one-fourth of imports from countries outside Europe, but only 15% of total imports.

Total European imports of forest products were valued at 25.7 billion dollars (U.S.) in 1985; the EEC accounted for 80% of this total. The Federal Republic of Germany and the United Kingdom are the leading importers in the EEC, together accounting for half of the group's total imports of forest products in 1985. France and Italy each account for roughly 13% of total EEC imports of forest products.

European exports of all forest products totaled 7.6 billion cubic feet, roundwood equivalent, 70% of regional roundwood production in 1985. The equivalent of more than 1.1 billion cubic feet of roundwood was exported to countries outside Europe; this was 15% of the total export volume. Pulp and paper products accounted for nearly 80% of the volume of exports to destinations outside the region; coniferous sawn wood (most of which originates in the Nordic countries) accounted for most of the rest. Major markets for European exports are the Middle East and Northern Africa (coniferous sawn wood), North and South America, and Japan (woodpulp, and paper products). Sweden and Finland are Europe's largest exporters of forest products; together they accounted for 40% of total exports (by value) in 1985. The Federal Republic of Germany, and France are the largest forest products exporters in the EEC, accounting for 50% of that group's exports, and 20% of the European total in 1985. However, both countries are net importers of forest products.

In 1985, Europe as a whole was a net importer of roughly 800 million cubic feet of forest products (roundwood equivalent). However, this was the result of 3.1 billion cubic feet of net exports by the nordic countries being offset by nearly 4 billion cubic feet of net imports by the rest of Europe (table 62). The European deficit with countries outside the region was roughly 300 million cubic feet. Net imports for all of Europe were valued at 3 billion dollars (U.S.), and amounted to 9% of industrial roundwood production, and 8% of regional consumption. The United Kingdom was the largest net importer in 1985 (4.4 billion dollars, U.S.), followed by the Federal Republic of Germany, and Italy. Together the countries of the EEC were net importers of 12 billion dollars (U.S.) in forest products. The members of EFTA were net exporters of 9 billion dollars (U.S.) in forest products in 1985.

In 1986 the United States imported 1.2 billion dollars of forest products from Western Europe (11% of total U.S. forest products imports, and 6% of European exports). Over 90% of these imports were fiber products (woodpulp and paper products); half of the total, by value, was printing and writing paper (other than newsprint). In the same year the United States exported to Europe forest products valued at 1.7 billion dollars (23% of U.S. forest products exports, and 5% of European imports). U.S. purchases of European forest products were equally divided between the EEC and EFTA. However, U.S. exports go primarily to countries in the EEC. The nordic countries in EFTA are the source of most U.S. imports from this association.

Forest Resources and Production

Detailed information on the forests of Europe was published in 1985; some of these data are summarized in table 63 (ECE/FAO 1986). There are 328 million acres of closed forest in Europe, less than 5% of the world total. Half of the European forests are privately owned. Nearly half of the forests of Western Europe (45%) are in the nordic countries, where private owners control 75% of the forests, and forest industry owns 15% of the forests. Private ownership of forests is lowest in the centrally planned economies of Eastern Europe. Only in the nordic countries is the forest industry share of forest land ownership comparable to that in the United States; forest industry owns roughly 18 million acres of the commercial forests in the nordic region. In all of Europe the forest industry owns approximately 6% of all commercial forest land.

Total growing stock of European forests in 1980 was 561.5 billion cubic feet, roughly two-thirds of which was coniferous (table 63). Total annual growth in 1980 (both coniferous and nonconiferous) was nearly 18 billion cubic feet, 3.2% of growing stock. Annual growth rates for coniferous species are highest in the EEC (nearly 5% of growing stock) as a result of extensive plantations in a number of countries, including France, Ireland, the United Kingdom, Portugal, and Spain.

Total roundwood removals in Europe were 12.7 billion cubic feet in 1985, having increased by nearly one-fourth (2.3 billion cubic feet) between 1950 and 1985 (table 64). Almost all of this growth was in coniferous removals. Nonconiferous timber production in Europe actually declined between 1970 and 1980; production in 1985 was roughly comparable to that in 1970. Total timber production for industrial products increased by more than 70% over the 1950–85 period; fuelwood production declined to less than 20% of total roundwood production in 1985, from more than 30% in 1950. Timber removals for pulpwood showed both the greatest relative growth, as well as the greatest absolute growth over the 35-year period. Roundwood removals in 1980 were 70% of growth for coniferous species, and 63% of growth for nonconiferous species.

Consumption of Forest Products

In 1985, European countries consumed roughly 41 billion board feet of sawn wood, 39 billion square feet of

Table 63.—European forest resources, 1980.

Region	Commercial forest[1]	Growing stock Coniferous	Growing stock Nonconiferous	Annual growth Coniferous	Annual growth Nonconiferous
	Million acres	*Billion cubic feet*			
Nordic[2]	119.3	130.1	24.7	4.1	1.0
EEC[3]	95.6	77.7	74.2	3.7	2.4
Other[4]	49.9	56.5	45.9	1.4	1.2
Total Western	264.8	264.9	144.8	9.2	4.6
Eastern[5]	63.7	88.3	60.0	2.4	1.6
Total Europe	328.4	356.7	204.8	11.6	6.3

[1]*Exploitable closed forests.*
[2]*Finland, Norway, and Sweden.*
[3]*European Economic Community (12 countries).*
[4]*Includes Austria, Switzerland, Turkey, Yugoslavia, Albania, Cyprus, and Israel.*
[5]*Communist block countries, excluding the Soviet Union.*
Source: ECE/FAO 1986: tables 3.2 and 3.6.
Note: Individual items may not add to totals due to rounding.

Table 64.—Roundwood removals and industrial wood production in Europe, by species group, and product group, for selected years 1950 to 1985.

Year[2]	Roundwood removals[1] Total	Roundwood removals[1] Coniferous	Roundwood removals[1] Nonconiferous	Industrial wood Sawlogs	Industrial wood Pulpwood	Industrial wood Other[3]
	Million cubic feet					
1950	10,379	6,028	4,351	3,454	1,317	1,310
1960	10,799	6,569	4,230	4,157	2,115	1,225
1970	11,891	7,459	4,432	5,074	3,309	1,088
1980	12,032	8,048	3,984	5,665	3,655	823
1985	12,723	8,256	4,467	5,618	3,869	968

[1]*Total removals, industrial wood and fuelwood.*
[2]*Data are a three year average, centered on the year shown; data reported for 1985 contain estimates for some countries.*
[3]*Other industrial wood products.*
Source: ECE/FAO 1986: tables 3.15 and 3.18.
Note: Data for Europe in 1985 differ slightly from those shown for Europe and the Nordic countries in table 62.

panels, and 59 million tons of paper and paperboard. Sawn wood consumption increased nearly 60% between 1950 and 1985; more than three-quarters of sawn wood consumption in 1985 was coniferous, and more than one-third was imported. Consumption of panel products showed the most dramatic change between 1950 and 1985, increasing by 1,200% (from 3 billion square feet in 1950). Most of the increase in panel consumption is attributable to particleboard; this group of panels accounted for two thirds of total wood-based panel consumption in 1985. Plywood accounted for roughly 15% of wood-based panel consumption in 1985.

Consumption of paper and paperboard in Europe increased by more than 400% between 1950 and 1985. Printing and writing papers (including newsprint) account for 40% of consumption in this product group, but growth in consumption of other paper and paperboard products accounted for most of the increase in total consumption.

Per capita consumption of all forests products (except fuelwood) also grew over the 1950 to 1985 period. Per capita consumption of wood-based panels increased most rapidly, followed by paper and paperboard. Per capita consumption of sawn wood increased only slightly (if at all) in most European countries. Per capita consumption (of all products) is highest in the more heavily forested nordic countries, and in central Western Europe (Austria and Switzerland). With the exception of paper and paperboard, per capita consumption in the nordic countries equals, or exceeds that in the United States. Paper and paperboard consumption in this region is comparable to Canada (roughly two-thirds of U.S. consumption).

Although the EEC accounts for half of European sawn wood consumption, 60% of wood-based panel consumption, and two-thirds of paper and paperboard consumption, this economic grouping has relatively low per capita consumption figures. In all three product groups, per capita consumption in the EEC is less than half that in the United States. In the EEC, the United Kingdom, the Federal Republic of Germany, Italy, and France are the major consumers of forest products.

Latin America

Latin America includes all countries in the Western Hemisphere south of the United States; diversity rather than similarity characterizes the countries in this region. In statistical terms, two countries are dominant in their respective subregions: Brazil in South America, and Mexico in Central America. Brazil has emerged as a major force, in economic terms, in all of Latin America, and is increasingly influential in the world economy (The Economist 1987a).

Most countries in Latin America are middle-income, developing economies (World Bank 1987). A few countries have average (per capita) incomes well above the regional average, even exceeding average income in some industrial market economies; at the other extreme, however, Haiti is among the poorest countries in the world. Regional average per capita income is 10% that of the United States.

Most Latin American economies experienced strong growth over the period 1965–80, and a sharp and deep recession during 1981–83. National incomes grew at an average annual rate of 5% for the period 1965–80; in 1981 regional income fell by 2% (World Bank 1987). During this recession most countries in Latin America experienced rising interest rates, high rates of monetary inflation, falling (export) commodity prices, and reduced foreign investment. The result was falling national incomes, sharply reduced imports, and substantial foreign debt. Regional external debt totaled over 350 billion dollars in 1986, nearly two-thirds of which was owed by Mexico and Brazil (The Economist 1987b).

Forest Resources

More than one-third of Latin America is forested; one-fourth of the world's closed forests are in this region. The forest resources of Latin America are extensive and diverse, but are not evenly distributed. The countries in the tropical region of South America are heavily forested (well over 50% of the land area is forest); countries in the southern temperate zone are less than 30% forested (United Nations 1985). Countries in Central America and the Caribbean region have significant areas of forest, but a much lower proportion of these forests is productive, closed forest. In 1980 a little over one-half (550 million hectares) of the nearly one billion hectares of forest in Latin America were classified as productive (United Nations 1981, 1985).

Although Latin America contains over one-fourth of the world's growing stock of timber, the region's indigenous forests, composed primarily of tropical hardwood species, have been long exploited and, in some areas, seriously depleted. Deforestation in the world's tropical forest regions has raised concerns among scientists and in the popular press, for local as well as global environmental reasons. There is no consensus, however, on the extent or severity of this problem (Lanly 1982). The island nations of the Caribbean, with the smallest relative forest area, have been most significantly affected; some face severe shortages of forest-based fuel and raw material (Lugo et al. 1981).

At the same time, other countries in Latin America—Brazil and Chile, for example—are noteworthy for programs establishing forest plantations composed of fast-growing, nonnative species. These plantations now account for a far greater proportion of national timber harvests than their share of either forest area or growing stock volume. Over 60% of the region's plantations are in Brazil, and roughly 15% are in Chile. More than half of the Brazilian plantations are fast-growing hardwood species; almost all of the plantations in Chile are fast-growing softwood species.

Forest Products Production and Consumption

In the two decades ending in 1985, forest products production and consumption in Latin America increased significantly. Total roundwood production increased by nearly 50%; production of industrial roundwood (timber used for manufactured products) increased by 150% over this period (United Nations 1986b). Production of roundwood for pulp in Latin America increased by nearly 500% between 1965 and 1985; over the same period world pulpwood production increased by only 63% (United Nations 1986b). Latin America now accounts for more than 8% of world pulpwood production, up from 2% in 1965.

This industrial development has been a response to regional demand for industrial wood products (driven by rising incomes and urbanization of the population) and the need to utilize abundant resources to support economic development. However, fuelwood remains the primary use of timber in Latin America; nearly three-fourths of the region's timber harvest was used for fuel (United Nations 1986b). Even when adjustment is made for the fact that as much as 15% of Brazil's fuelwood production may be used for industrial fuel (Sedjo 1980) the fuelwood share of total wood production in Latin America is well above the world average of 50%.

Brazil, Chile, and Mexico are the major timber-producing countries in Latin America; Argentina, Paraguay, Ecuador, and Colombia are smaller producers, but are nevertheless important. Brazil produces well over 60% of the region's roundwood (both total roundwood, and roundwood used for industrial products); in 1986 Chile produced more than 10% of the region's industrial roundwood, Mexico produced 8%, and Argentina, Paraguay, Ecuador, and Colombia together produced roughly equal shares of another 14% of the total (United Nations 1986b).

Brazil is the region's leading producer of manufactured forest products, accounting for over half of Latin American sawn wood and panel output, and nearly half of the region's paper and paperboard production (United Nations 1986b). Regional production, however, is less than one-third of U.S. production. Unlike production in the United States, the majority of forest products in Latin America utilize nonconiferous species; in contrast, the United States is largely a coniferous species-based forest economy.

As a result of its share of the region's population (roughly one-third), and its industrializing economy, Brazil is also the largest single consumer of forest products in Latin America. Most of the growth in forest products consumption in Brazil, as well as that in the rest of Latin America, occurred over the period 1965–80. Total forest products consumption remained roughly constant between 1980 and 1985; in some countries consumption declined. The 1981–83 recession had a more pronounced impact on forest products consumption (and imports) than on forest products production (and exports) because many countries pursued policies that controlled domestic consumption through import restrictions, while expanding the production and export of domestic resource-based industries.

Forest Products Trade

Latin America is a net importer of forest products in terms of value. Only in Brazil and Chile, and to a much smaller extent in Paraguay and Honduras, does the value of forest products exports exceed the value of forest products imports. All Caribbean countries are net importers of forest products, as are all Central American countries other than Honduras. Mexico, Venezuela, Argentina, Ecuador, and Trinidad and Tobago are now the region's major net importers of forest products. A number of countries—among them Mexico, Argentina, and Ecuador—are noteworthy as both exporters and importers of forest products. For many of these countries the mix of forest products exports is composed of products of relatively low unit value (logs, veneers); their forest products imports, however, are primarily high-value manufactured products (panels, paper and board products).

The United States annually exports over one billion dollars worth of forest products to countries in Latin America. Exports to Latin America account for approximately 14% of total U.S. forest products exports; the United States is the major extraregional supplier of forest products to Latin American markets. The United States supplies over 40% of the value of forest products imported by all Latin American countries; intraregional trade accounts for most of the rest of this trade.

The value of forest products exported to individual countries in Latin America is modest compared to, for example, the value of U.S. forest products exports to Japan; in 1986 forest products exports to Japan were valued at over 2 billion dollars. Exports to Mexico, the largest single market in Latin America, were 446 million dollars in 1986. The Latin American market is considerable in total, however, and is significant to U.S. exporters of particular commodities. Over 20% of all U.S. fiber products exports go to this region; fiber products (pulp, paper, paperboard and related products) are approximately 90% of total forest products exports to the region. Latin American countries have purchased over 50% of U.S. newsprint exports in recent years, and 40% of U.S. paper and board products exports.

Latin America is also the destination of 40% of hardwood plywood exports, and 30% of U.S. particleboard exports. The Caribbean Basin (including Mexico) is the primary export market for southern pine lumber; Mexico is the third largest importer of softwood lumber from the United States.

Although Latin America accounts for less than 5% of total U.S. forest products imports, imports from Latin America more than doubled over the period 1980–87. Almost all of this increase is the consequence of a 500% increase in the value of imports of fiber products. This broad commodity group that accounts for most of our exports to Latin America is now our most rapidly growing import from that region. Most of the recent increase in fiber product imports from Latin America is pulp from Brazil, and paper products (especially newsprint) from Mexico.

The United States is a net exporter of forest products to Latin America. The U.S. forest products trade surplus with this region, nearly one billion dollars in 1980, dropped to less than 500 million dollars in 1986, however. The United States is a net importer of forest products from Brazil; the deficit in this bilateral trade has been increasing as Brazil substitutes domestic production for imported products and realizes greater success in penetrating U.S. markets. The U.S. forest products trade surplus with Mexico decreased by nearly 50% over the period 1980–86 as a result of a combination of a weak Mexican economy (reducing Mexican imports of U.S. goods) and a dramatic decline in the value of the peso (doubling U.S. imports from Mexico).

Recent trends in trade with Latin America may be misleading, however. As a result of the recession of 1981–83, domestic demand for forest products in Latin American dropped sharply and, in some countries, had not recovered by the end of the decade. The decline in imports of all products, including forest products, is largely attributable to weak domestic demand rather than to import substitution. At the same time, many countries in the region have made an effort to maintain (or increase) export earnings in order to make payments on external debt, and support the consumption of other goods. The forest sector has been targeted by some countries (Brazil and Chile, in particular) as a potential source of valuable foreign exchange.

CHAPTER 6. MAJOR DEMAND AND SUPPLY ASSUMPTIONS

All projections are consequences of assumptions and in this assessment these assumptions concern the major determinants of the supply and the demand for various forest products. These assumptions are required as inputs in the model of the forest sector[18] used in this Assessment. The primary forest sector model (The Timber Assessment Market Model—TAMM[19]) was originally developed for the 1979 RPA Assessment. It is based on systems analysis and quantitative techniques and has been extensively revised for this Assessment. This chapter provides a summary of the major assumptions employed in the model.

BASIC ASSUMPTIONS

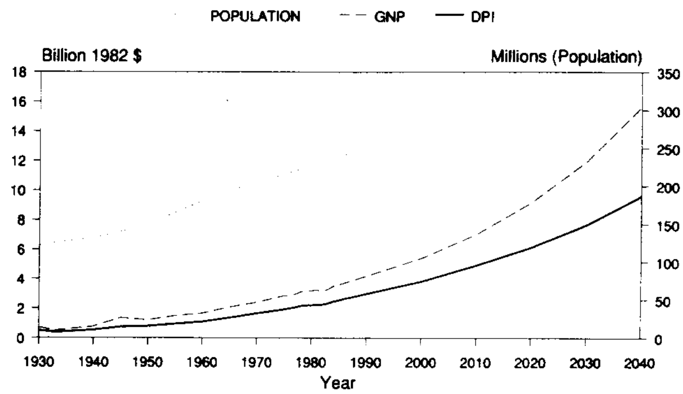
In the future, as in the past, demand for and supplies of forest products will be largely determined by such things as growth in population, income, and economic activity; technological and institutional changes; energy costs; capital availability; and investments in management, utilization, assistance, and research programs for forest, range, and water resources.

Past trends in these determinants have resulted from social, political, technological, and institutional forces that are not easily or quickly changed. The following assumptions are based on these trends, current knowledge about developments affecting these trends, and present expectations about future changes generally accepted as reasonable at this time.

Population

Over the last five decades, the population of the United States increased by more than 100 million people, to about 242 million in 1986 (fig. 53, table 65). Projections by the WEFA Group using Bureau of the Census (USDC 1984, The WEFA Group 1987) assumptions about future demographic developments indicate that population will continue to grow (although at declining rates) and should reach 333 million in 2040. The Bureau of the Census assumptions are the "middle series" projections developed by the agency. The sole exception is that net immigration is assumed to be 750,000 people per year in an attempt to account for net illegal immigration.

Although the population continues to expand, the annual rate of growth declines from about 1% currently to .2% by 2040. This decline in the growth rate depends, in part, on fertility rates that are assumed to remain roughly constant (around 1.8 births per woman) throughout the projection period. This is consistent with recent levels of fertility, expected number of births per woman's lifetime, and social and economic trends that tend to maintain low fertility; increases in female labor force participation, educational attainment and age at first marriage.



Source: Council of Economic Advisors 1987, WEFA 1987.

Figure 53.—Historical and projected gross national product, disposable personal income and population.

Fertility rates have fluctuated widely since World War II but fell from the late 1950s when they peaked at more than 3.6 births per woman through the mid-1970s when they ranged between 1.7 and 1.8 births per woman. In 1986, the fertility rate was 1.9 births per woman. This fertility rate is below the replacement rate (2.1 births per woman) and eventually in the late 2020s the crude death rate is expected to exceed the birthrate (Bureau of Census 1989). Growth in population after that time will be due to net immigration.

Under these conditions, the population (and the labor force derived from it) gradually ages with significant increases in the fraction of the population over retirement age (65–70 +). This has important implications for the composition of aggregate demand in the economy (larger increases in demand for services, particularly health and retirement related, and slower growth in demand for both durable and nondurable goods), the composition of governmental expenditures (with large shifts into health and retirement), and ultimately the demand for housing and its composition in terms of types of dwellings.

The geographic distribution of the population has a strong influence on state and regional demands for renewable resources. State projections prepared by the Bureau of Economic Analysis (USDEA 1985) are used as the basis for regional projections of demands.

Economic Activity and Income

Perhaps the most commonly used measure of aggregate activity in the economy is gross national product (GNP) expressed in constant dollars (1982 dollars, net of inflation and deflation). Forecasts of future potential

[18]*A forest sector model, in general, combines activities related to the use of wood: forest growth and harvest; the manufacture of pulp, paper, and solid-wood products; and international trade and intermediate and final consumption of these products (Kallio et al. 1987).*

[19]*The original model is described in Adams and Haynes (1980) and Haynes and Adams (1985).*

Table 65.—Population, gross national product, and disposable personal income in the United States, selected years, 1929-86, with projections to 2040.

Year	Population		Gross national product		Disposable personal income		Per capita disposable personal income	
	Millions	*Annual rate of change*	*Billion 1982 dollars*	*Annual rate of change*	*Billion 1982 dollars*	*Annual rate of change*	*1982 dollars*	*Annual rate of change*
1929	121.8	—	709.6	—	498.6	—	4,091	—
1933	125.7	0.8	498.5	-8.4	370.8	-7.3	2,950	-7.8
1940	132.1	0.8	772.9	7.9	530.7	6.2	4,017	5.4
1945	139.9	1.1	1,354.8	-1.9	739.5	-1.3	5,285	-2.4
1950	151.7	1.7	1,203.7	8.5	791.8	7.1	5,220	6.2
1955	165.3	1.8	1,494.9	5.6	944.5	5.6	5,714	3.8
1960	180.8	2.1	1,665.3	2.2	1,091.1	2.2	6,036	.1
1965	194.3	1.3	2,087.6	5.8	1,365.7	5.8	7,027	4.5
1970	205.1	1.2	2,416.2	-.3	1,668.1	4.3	8,134	3.1
1975	216.0	1.0	2,865.0	-1.3	1,931.7	1.9	8,944	.9
1976	218.0	0.9	2,826.7	5.3	2,001.0	3.6	9,175	2.6
1977	220.3	1.0	2,958.6	4.7	2,066.6	3.3	9,381	2.2
1978	222.6	1.1	3,115.2	5.3	2,167.1	4.9	9,735	3.8
1979	225.1	1.1	3,192.4	2.5	2,202.6	2.1	9,829	1.0
1980	227.7	1.2	3,187.1	-0.2	2,214.3	0.1	9,723	1.1
1981	230.1	1.0	3,248.8	1.9	2,248.6	1.5	9,773	0.5
1982	232.4	1.0	3,166.0	-2.5	2,261.5	0.6	9,732	-.4
1983	234.8	1.0	3,279.1	3.6	2,331.9	3.1	9,930	2.0
1984	237.1	0.9	3,501.4	6.8	2,469.8	5.9	10,419	4.9
1985	239.3	1.0	3,607.5	3.0	2,542.2	2.9	10,622	1.9
1986	241.6	1.0	3,713.3	2.9	2,645.1	4.0	10,947	3.1
				PROJECTIONS				
2000	274.9	0.7	5,402	2.8	3,827	2.4	13,920	1.6
2010	294.3	0.6	7,031	2.6	4,922	2.3	16,730	1.6
2020	312.1	0.5	9,166	2.8	6,136	2.4	19,660	1.8
2030	325.5	0.3	11,957	2.7	7,660	2.2	23,530	1.9
2040	333.4	0.2	15,627	2.7	9,599	2.3	28,790	2.1

Sources: Historical Data—Council of Economic Advisors 1987. Projections—WEFA 1987.

GNP are derived from assumptions about the size of the work force (number of workers) and its productivity (GNP per employed worker). The number of workers, in turn, depends on the size of the population and the fraction of individuals seeking employment (called the labor force participation rate). Growth in potential GNP is the sum of growth in the work force and growth in productivity. Historical data and projections for these concepts are shown in table 66.

Projected labor force participation rates continue to rise in the future, though less rapidly than in the past. Resulting growth in the labor force exceeds that for the population as a whole (compare rates for population in table 65). Female participation shows the strongest increase. The rate for males, which dropped steadily over the past 30 years, is nearly stable. The age structure of the population is also important. Increasing numbers of persons in the 65 + age classes, with traditionally lower participation rates, acts to retard growth in the labor force.

Over the past two decades growth in worker productivity (GNP per worker) has fallen sharply to levels well below 1% per year. The projections envision a rebound in the productivity growth to levels more nearly comparable to those observed in the 1950s and 1960s. As labor force growth slows in the future, competition for available workers will increase and wages will rise. To parti-

Table 66.—Labor force and gross national product (GNP).

Year	Labor force participation rate	Labor force	Labor force growth	GNP per worker	Growth in GNP per worker	Potential GNP growth
	Fraction	*Mill*	*%/year*	*M$ 1982/ worker*	*%/year*	*%/year*
1952	.39	61.5		22.9		
1960	.39	70.5	1.73	27.4	2.27	3.29
1970	.40	82.0	1.38	30.7	1.14	2.52
1976	.44	95.9	2.64	32.3	0.85	3.49
1986	.49	118.4	2.13	33.5	0.36	2.49
2000	.50	142.9	1.35	40.6	1.38	2.73
2020	.56	174.8	1.01	55.5	1.58	2.59
2040	.64	213.4	1.00	77.9	1.71	2.71

Source: WEFA 1987.

ally offset these increased costs, industry is expected to invest in capital equipment, thereby expanding worker productivity. An aging, but more experienced and better trained work force will also boost productivity.

Potential GNP growth during the 1950s and 1960s averaged roughly 4% per year, falling to 3% in the 1980s. The result of assumed growth in labor force and worker productivity in the present projections is potential GNP growth which averages roughly 2.7% per year by 2040.

Assumptions about future price levels, interest rates, and wage rates are shown in table 67. Inflation is projected to average roughly 4.5% per year until 2000, but in the longer term, aggregate demand moderates with the aging population and inflation gradually declines to an average of 4% in the period to 2040. Wage rates rise slightly faster than the inflation rate given the expected increases in per capita GNP.

These projections assume that a gradual tightening of federal spending and relatively modest tax increases lead to a net aggregate government budget surplus by 1995 and a balanced federal budget by 2005. With a gradual lessening of U.S. needs for off-shore financing and assuming no significant intervention to shore up the dollar, interest rates drop somewhat faster than inflation. Consequently, real interest rates fall to the 3% range by 2040.

Adjusting potential GNP for government monetary and fiscal actions, actual investment, foreign trade, unemployment and inflation, projections of observed real GNP are as tabulated in table 65. Growth is expected to range between 2% and 3% over the next 50 years, in contrast to the 3-4% range characteristic of the past three decades. This leads to an approximate quadrupling of GNP in the next five decades as opposed to a five-fold increase over the past 50 years. Paralleling expansion in GNP, total disposable personal income increases more than three times (see table 65) and some 2.5 times on a per capita basis. Though anticipated economic growth is somewhat slower than in the past, this projection still portrays a strong and resilient future economy, with a larger and increasingly affluent population.

Technological and Institutional Change

Past changes in demands and supplies have reflected the interactions of the influences of institutional and technological changes. It is assumed that the stream of institutional and technological changes will continue at similar rates in the future. Assumptions on important technological changes affecting product yields and other uses of the renewable resources are specified in the Assessment documents as appropriate.

Institutional changes that lead to the reservation of forest and range lands for designated uses such as wilderness, parks, and wildlife refuges have occurred for a long time. This development is specifically taken into account in the projections of forest and rangeland areas.

Table 67.—Inflation rate, interest rate, and wage rate projections.

Year	Inflation[1]	Interest rate[2]	Growth in Wage rate
		Percent	
1986	2.6	9.7	3.1
2000	4.5	9.5	5.7
2010	4.7	9.3	5.7
2020	3.6	8.8	3.8
2030	4.8	7.9	5.4
2040	4.0	7.9	4.5

[1]*Rate of growth in the implicit GNP deflator.*
[2]*Interest rate on long-term bonds.*
Source: WFEA 1987.

Energy Costs

The long-term outlook for energy costs is for a resumption in growth despite sharp price drops in the 1980s. Projections by the U.S. Department of Energy (in press) provide a rough view of trends through 2010. These projections show world crude oil prices increasing from $12.22 in 1986 to $47.27 per barrel in 2010:

Year	Dollars per barrel
1986	12.22
2000	29.68
2010	47.27
2020	50.00
2030	50.00
2040	50.00

Prices are in 1982 dollars, net of inflation or deflation. If the Department of Energy projections were extrapolated to 2040, the price per barrel would be near $100 in 2040. This price was judged so high as to be unreasonable in that conservation and development of alternative energy sources would act to slow the rate of increases in energy prices. As a result, the price per barrel was assumed to level off at $50 in 2020 and stay at this price through 2040. Rising energy prices are assumed to induce various technological changes that would partly offset these price increases. These price increases have also been used to project demands for fuelwood.

Capital Availability and Investments

Capital availability for plant expansion has occasionally been raised as an issue in making judgments about the likelihood of realizing future output levels. Over the years, there have been little analyses of this question but scant results have been supportive of the assumption that capital would not be a limiting factor for future production levels. Indeed, the WEFA projections of growth in gross national product are suggestive of a growing economy with sufficient capital generation to realize the capacity expansion and improvements called for in the assessment projections.

With regard to the timberland base, future timber supplies will be determined in large measure by the level of investments. In the base assessment projection the levels of future management intensities are assumed to be at levels consistent with trends of the last two decades.

DEMAND ASSUMPTIONS FOR SOLID-WOOD

Projections of demand for lumber, structural panels, and nonstructural panels were based on the end-use approach employed by the Forest Service in previous Assessments. The projection method for lumber and structural panels was modified to explicitly incorporate prices of products and their substitutes in making projections. The end-use approach depends on isolating markets by individual end-use categories selected to represent specific applications of the products, such as framing or sheathing of floors. Where lack of data precludes such specific breakdowns, more general categories were selected, such as combined use of lumber in shipping and manufacturing.

In this approach, the consumption of a market in a particular end-use is estimated by multiplying the level of an end-use activity times the consumption per unit of end-use. This requires assumptions about the levels of activity in each end-use category and the consumption of various forest products per unit of end-use activity. Both of these sets of assumptions are discussed in this section.

Determinants of End-Use Activity

Projections of end-use activity derive directly from the population, economic activity, income, and energy cost assumptions described above. Key end-use activity concepts include the number of housing starts and house size, levels of expenditures on residential upkeep and improvement, levels of expenditures for nonresidential construction, the index of manufacturing production and measures of activity in shipping and transportation.

Housing

In terms of volumes consumed, residential construction has been the dominant market for most timber products. Analyses based on projections of the factors that determine long-term demands for new housing units—household formations, replacement of units lost from the housing stock, and maintenance of an inventory of vacant units—indicate continued high levels of demand in the late 1980s, resulting in an average of nearly 2.0 million units for the last half of the decade (table 1). Housing demand remains at about 2.0 million units in the early 1990s, and subsequently drops to roughly 1.7 million starts by 2010, and declines to 1.5 million starts by 2040. After 2010 a larger fraction of the starts are for houses that replace individual units in the housing stock that are being retired (table 68).

The type of housing units demanded (single-family, multifamily, mobile home) is important in projecting demands for timber products because of the large differ-

Table 68.—Projections of number of households, housing starts, and replacement assumptions.

Year	Number of households	Total starts	Discards	Net additions	Net replacements
		Millions			
1986	88.6	2.111	.68	.480	.200
2000	109.9	1.868	.772	.344	.428
2010	121.0	1.640	.815	.199	.616
2020	132.4	1.850	.846	.313	.533
2030	142.3	1.691	.887	.283	.604
2040	150.3	1.545	.920	.301	.619

	Total starts	Single family	Multiple	Mobile
		Millions		
1986	2.111	1.191	.640	.280
2000	1.868	1.253	.268	.347
2010	1.640	.980	.380	.280
2020	1.850	1.141	.409	.300
2030	1.691	1.023	.368	.300
2040	1.545	.916	.329	.300

ences in the average amounts and types of timber products used in each type.

Single-family houses are typically occupied by households whose heads are in the middle-age classes, while occupancy of units in multifamily buildings and mobile homes is highest among households headed by younger and older persons. As a result of prospective shifts in the age distribution of the population, and the associated changes in household types and income, the numbers of conventional single-family units demanded are projected to fluctuate but generally remain near 1.1 million through most of the projection period. The exception is the decade of 2000–2010 when the number of new household formations is low. The numbers of multifamily units demanded show the same trend. Demand for mobile homes—most of which will be produced for primary residential use and are expected to become larger and more houselike—remains constant at 300,000 units a year through the projection period. This is just slightly larger than the number of mobile units discarded each year.

In addition to the numbers of new units demanded, their size is also an important determinant of the amount of timber products used in housing. The average size of single-family housing units, though showing some fluctuation, has grown fairly steadily over the past 35 years, rising from nearly 1,150 square feet in the early 1950s to about 1,825 square feet in 1986. This increase in floor area has offset a declining trend in wood use per square foot of floor area and resulted in roughly constant average lumber use per single-family unit. The size for units in multifamily structures has also increased; however, the rise has been somewhat smaller and more erratic. For example, the size of average new multifamily units in 1986 was about 911 square feet, 15% above the average in the early 1950s, but down 10% from the mid-1970s. Average floor area in new mobile homes, which more than doubled between 1950 and the mid-1970s, has continued to rise because of the increasing share of double-wide and expandable units.

Rising incomes and consumer preference for more space are assumed to lead to continued future growth in average size of all types of units. However, because of rising land costs and decreasing household size with an aging and less fecund population, such increases are expected to be slower than in the past. For example, the average floor area of single-family houses is projected to reach 2,010 square feet by 2040, an increase of less than 0.25% per year. Growth between 1950 and 1986 averaged about 1.4% a year. The size of units in multifamily structures is expected to rise to 1,110 square feet, about 75 square feet above the average in the mid-1970s.

Residential Upkeep and Repair

In addition to the timber products consumed in the production of new housing units, substantial and growing volumes—about 20% of lumber and structural panel products and 15% of nonstructural panel products—are used each year for the upkeep and improvement of existing units. Expenditures for residential upkeep and repair have in the last several years averaged nearly $600 (1982 dollars) per household. This is almost twice the level observed in the early 1970s. Such growth is expected to continue in the future as the Nation's inventory and average age of housing units increase. The housing stock is expected to increase from 98.1 million units in 1986 to 166.3 million units in 2040. The average age of this stock is expected to increase from roughly 50 years to 90 years during the same period.

Projections of expenditures for residential upkeep and repair are shown in table 69. These projections assumed a fixed level of expenditures per household (expressed in 1977 dollars). Assuming a stable vacancy rate, this projection is equivalent to a constant upkeep and repair expenditure per housing unit. As the housing inventory grows and ages so does the aggregate expenditure on upkeep and repair.

New Nonresidential Construction

In recent years about 10% of lumber, plywood, and other structural and nonstructural panel products have been used in the construction of offices, stores, churches, and a wide variety of other nonresidential buildings, and in other types of construction such as roads, dams, and water and sewer systems. Although expenditures for the various classes of construction have fluctuated widely in response to changing economic conditions, the long-run trend for all types combined has been strongly upward.

Projections based on the close historical relationship between changes in gross national product and changes in expenditures for nonresidential building and nonbuilding construction indicate substantial additional

Table 69.—Projections of major determinants of solid-wood products demand.

Year	Residential repair and remodeling expenditures	Value of nonresidential construction	Index of manufacturing	Pallets
	Billion 1977 dollars		*1967=100*	*Millions*
1986	48.5	123.6	178.6	373
2000	57.7	145.8	272.4	397
2010	64.4	160.4	361.3	472
2020	70.2	176.8	477.9	525
2030	73.9	194.7	621.6	575
2040	76.7	214.7	815.3	600

expenditures over the next five decades (table 69). However, the rates of growth underlying these projections drop throughout the projection period. New nonresidential construction expenditures also decline as a percentage of gross national product. This is consistent with trends since the late 1960s, and with estimates that the service industries will account for a growing share of gross national product in the years ahead.

Manufacturing

Since the mid-1970s about 10% of the lumber, 5% of the structural panel products, and nearly 25% of the nonstructural panel products have been used for the manufacture of a wide range of products such as household furniture—the largest manufacturing use of timber products—sports equipment, games and toys, and commercial and industrial equipment.

Since World War II, U.S. demands for manufactured products have increased markedly reflecting increased population and incomes. Projections based on the close correlations between the values of shipments of certain groups of manufactured products, the index of industrial production for other groups of manufactured products, and projected changes in the economic and demographic variables discussed earlier, indicate continued growth in the years ahead (table 69). However, as in the case of nonresidential construction, the rates of increase in the value of shipments for all groups of products, including household furniture, drop significantly over the projection period.

Shipping

In recent years, nearly 18% of the lumber and about 3% of the structural and nonstructural panel products consumed have been used in the production of wooden pallets, containers, and for dunnage, blocking, and bracing of goods for shipping. Pallets account for about three-fourths of the lumber and nearly two-thirds of the panel products consumed in shipping.

During the past three decades, pallet production rose rapidly with the introduction of new methods of materials handling, the construction of facilities geared to the use of pallets, and increases in the volumes of manufactured and agricultural goods shipped. The rate of increase in the post-1982 recession period has been especially rapid. Projections of pallet output are based on the relationship of pallet use to the value of manufacturing shipments and the assumed growth in shipments as the gross national product rises (table 69). These projections indicate gradual increases mirroring the increase in gross national product.

Although increased demand for pallets is expected over the entire projection period, the rate of growth drops rapidly. This decline reflects competition from alternate systems and materials, and means that growth in pallet demand for use in new materials-handling systems gradually ends. Future expansion thus depends to a large degree on growth in industrial and agricultural production.

The other timber products shipping markets—wood containers, and dunnage, blocking, and bracing—are likely to decline slowly over the projection period in response to continued displacement by metal and fiber barrels and pails, and other fiber and plastic containers, and due to the rising use of palletized, containerized, and other bulk shipment systems.

Trends in Unit Use

Projected demand also depends on changes in product unit-use factors—the volume of timber products used per square foot of housing unit floor area, per dollar of construction expenditure, per pallet, or other measure of market activity. Assumptions regarding the trends in use factors are derived in two ways. For nonstructural products, projections of product-use factors for the major markets have been based on current trends, modified to be consistent with expected future movements of relative prices and associated changes in the various nonprice factors. In general, this procedure has resulted in a continuation of recent trends in the various unit-use factors. For example, additional decreases in the factor for particleboard use in housing and other light building construction are projected because of the likely penetration of oriented strand board/waferboard products in these uses caused by price and environmental factors.

After 2000, the projected rates of increase or decrease for the various product unit-use factors have been reduced, recognizing that continued change becomes more difficult as markets are saturated or as market share approaches zero. This phenomenon, which can be due to price or other factors, has apparently taken place in the case of insulation board used in residential construction where there has been displacement by other products.

For lumber and structural panels, projected use factors were based on two calculations. First, upper and lower limits for each factor were calculated. The upper limit calculated the potential levels that use factors may reach if only the wood product in question were used. Similarly, the lower limit estimated potential levels to which use factors may fall if completely displaced by competing products. This need not be zero. Nonzero lower limits imply some end-use elements where there are no technically or economically feasible substitutes foreseen over the projection. These limits define the range of possible use-factor variation through time.

Second, the actual path of the use factors within these limits was projected based on the relative in-place costs of key competing products. In-place cost projections are based on calculations regarding the amount of inputs required to install each competing system and the prices of these inputs. The change in use factors depends on which product's position is favored by the in-place cost comparison. When the wood product is less expensive, then the use factor is raised. When the competing product is less expensive, then the use factor is reduced. The amount of change is partly determined by functional relationships derived from numerical analysis of past use-factor trends (Spelter 1984, 1985b), and varies with the product and proximity of the use factor in relation to its limits.

The projections of demand contained in this assessment depend on these estimated relationships and on assumptions regarding relative in-place costs and end-use activities.

Demand for Pulpwood

The method used to project demand for pulpwood was based on projected demand for paper and paperboard products. The pulp and paper sector model (the Forest Products Laboratory (FPL) Pulpwood Model) was used to project technological change in fiber requirements and to project the allocation of production among supply regions, given projected North American demand for principal paper and paperboard grades. Paper and paperboard demand formulas for each product grade were derived by statistical regression of historical consumption data on historical per capita GNP, population, and price data. Demand coefficients for per capita GNP and population were then adjusted downward subjectively based on such considerations as the advancing age structure of population in North America, improvements in the efficiency of paper and paperboard use, and substitution of plastics and electronics technology for paper and paperboard products. The downward adjustments to demand coefficients result in substantially slower projected growth rates for paper and paperboard demand in future decades than was experienced in recent decades. However, demand continues to grow among almost all grades, and projections are consistent with recent industry forecasts.

TIMBER SUPPLY ASSUMPTIONS

In this assessment, the supply of timber at any point in time is modeled as a function of the private timber inventory levels, stumpage prices, and the amount of public harvest available at that time. The method used to project timber supplies requires assumptions relating to timberland area change, the efficiency of harvest utilization, and harvest flows from public timberlands.

Inventory Projection System

The aggregate timberland assessment system (ATLAS) was used to make inventory projections for the private ownerships (Mills and Kincaid, in press). The ATLAS model evolved from earlier systems developed to answer timber supply questions in the context of policy analysis (Beuter et al. 1976, Tedder et al. 1987). Previous timber assessments were made using TAMM and the timber resource analysis system (TRAS) (Larson and Goforth 1974); the new combined model is referred to as TAMM90/ATLAS.

Whereas TRAS is a diameter class model, ATLAS is age-based. Yield tables project acres by detailed strata for periods consistent with inventory stand-age classes. A major attribute of the model is that it can simulate shifts in management intensities and consequent changes in yields based upon alternative assumptions about the future.

The inventory in ATLAS is represented by acre-volume cells classified by region, ownership, management type, management intensity, and age class. The strata were also identified by three site productivity classes in the South and in the Pacific Northwest Douglas-fir region. A total of 18 age classes were used; 5-year classes were used in the South, and 10-year classes were used in all other regions. In each simulation period, inventory volume change is the result of growth, area change, and timber harvest. Growth is the result of an interaction between the current stocking, the base yield table, and the stocking change function (approach-to-normal assumption). Generally, a cell volume follows an upward sloping net yield trajectory. Each cell in the starting inventory may have an independent yield function, whereas, all regenerated acres in the same strata follow identical yield trajectories.

Inputs to the model include estimates of harvest, acreage shifts, and growth parameters. The ATLAS model is not, in principle, an even age model because it can simulate growth and removal processes across several age classes and it can account for both partial harvests and commercial thinning. The levels of harvest are derived through interaction with TAMM. Final harvested acres may be regenerated in alternative management levels, assumed to change timber type, or leave the timberland base entirely. Area change information by forest ownership and forest management type is provided as an input (see next section). Yield tables and approach-to-normal parameters were derived from the timberland inventory plot data collected by the various USDA Forest Service Forest Inventory and Analysis Units, parameters developed for use in previous studies, and yield tables developed from other models and from published sources. (The inventory data inputs and assumptions are summarized in Mills 1989.)

Projected Area Changes for Forest Ownerships and Forest Management Types

Projections of timber supply and corresponding prices are sensitive to the assumptions made regarding future forest area (Alig et al. 1983). These assumptions include changes in area by ownership, forest management type, and site.

In addition to changes in the area of total timberland, area changes for ownerships and forest management types may not only impact prospective timber supplies, but supplies of water, wildlife, forage, and outdoor recreation. Change in total timberland area is the net result of the conversion of timberland to nonforest and the shifting of nonforest to timberland by natural reversion or afforestation. Ownership changes in the timberland base may result in different land management objectives or new owners with different available resources to invest in forest management. Changes in the areas of forest types often reflect differences in land management objectives among owners, and indicate the differential influence of natural and management forces.

Projections of area changes for the timberland base were made for the North, South, Rocky Mountains and Great Plains, and the Pacific Coast. Within sections, projections were made for two private forest ownership classes—forest industry, and farmer and other private—and public timberland projections were provided by public agency personnel. The area projection methods and results are described in more detail in a supporting technical document (USDA FS 1989b) and state level projections are discussed by Alig and others (in press).

Trends in Timberland Area

Area of timberland in the United States steadily declined as the country was settled. This trend persisted until around 1920. Starting then, and continuing until the early 1960s, the acreage of timberland increased by about 50 million acres as the worked-out cotton lands in the South, cleared areas on hill farms in the East, and marginal farms in other regions reverted back to forests. By 1962, the timberland area in the United States reached 515 million acres (table 70).

During the 1960s, the upward trend in timberland area was reversed and by the 1970s, the rate of acreage loss begin to accelerate. As a result, timberland area declined 5% between 1962 and 1977 to 491 million acres. Between 1977 and 1987, timberland area dropped to 483 million acres; however, the rate of decline in timberland area lessened to about 2%, partly because of surplus crop production in the agricultural sector.

Area changes in timberland reflect the interaction of a number of forces. Timberland conversion takes place as the result of land clearing for highways, powerlines, and reservoirs, along with urban development. Public lands have been withdrawn, largely in the West, for parks, wilderness, and other recreation uses. Private lands have been acquired for second homes or recreation use. At the same time, additions to the timberland base from idle crop and pasture land have recently been increasing.

Projecting area change requires the consideration of complex economic and social factors. Thus, a mixture

Table 70.—Area of timberland in the United States, by ownership and region, specified years 1952–1987, with projections to 2040.

Ownership and region	1952	1962	1970	1977	1987	Projections 2000	2010	2020	2030	2040
	Million acres									
Ownership										
Public	152.8	152.5	150.2	144.2	136.3	134.3	134.3	134.3	134.3	134.1
Forest industry	59.0	61.4	67.6	68.9	70.6	71.5	71.5	71.4	71.3	71.0
Farmer and other pvt.	297.0	301.2	286.3	278.0	276.4	270.0	266.9	262.9	259.7	257.5
Total	508.8	515.1	504.1	491.1	483.2	475.8	472.7	468.6	465.2	462.6
Region										
North	154.3	156.6	154.4	153.4	154.6	154.4	153.6	151.7	150.5	149.5
South	204.5	208.7	203.3	198.4	195.4	191.3	190.0	188.6	187.4	186.8
Rocky Mountain	66.6	66.9	64.5	60.2	61.1	59.9	59.7	59.5	59.4	59.2
Pacific Coast	83.4	82.9	81.8	79.1	72.1	70.2	69.5	68.7	68.0	67.1
Total	508.8	515.1	504.1	491.1	483.2	475.8	472.7	468.6	465.2	462.6

Note: Data for 1952 and 1962 are as of December 31; all other years are as of January 1.
Source: Waddell et al. 1989.

of judgement and quantitative models was used to make projections of timberland area.[20]

Timberland by forest ownership was stratified into three site quality classes. The distribution across these classes was assumed to be constant given the general lack of data indicating otherwise. This was consistent with historical trends in the South, the section with perhaps the most frequent landscape changes affecting timberland (e.g., Alig et al. 1986).

Private Lands

The assumptions required to project the diverse set of variables that influence land use changes on private lands are described here. These assumptions were made based on historical trends, developments that affect those trends, and expectations regarding future changes. Assumptions used in making projections for population, personal income, and inflation rates are those shown in tables 65 and 67.

Many of the forces that have caused the recent changes in area of timberland will likely continue to influence changes in the future. Thus, in making projections of area changes, it has been assumed that determinants such as population, income, agricultural productivity, agriculture exports, and prices of agricultural crops and timber products would continue to influence land use changes (e.g., Alig 1985).

The amount of land used for agricultural purposes has a great impact on the amount of timberland available. Assumptions on the future rate of change in agricultural productivity and associated land incomes were derived from the 1986 RCA Appraisal (USDA SCS 1987). Assumptions on the annual rates of increase in yield vary by crop, but the rate of increase up to the year 2000 is higher than the 2001–2030 rate of increase in all cases. For example, productivity for field crops was assumed to increase by 1.9% annually up to the year 2000 and then slow down to 1.2% annually. Real product prices for agricultural products are assumed to remain constant over the projection period. Slow increases in the export of agricultural products are projected. Livestock incomes were projected assuming constant real prices and forage yields are assumed to increase at 0.7% per year.

Timber product prices rise in line with stumpage price projections from this assessment (see Chapter 7). Interaction with these price projections allows acreage trends to respond to economic forecasts.

Public Lands

Timberland area projections for the national forest ownership were made by the National Forest System and reflect the ongoing forest planning process (Alig et al., in press). Projections for each region include any withdrawals for roads, powerlines, reservoirs, wilderness areas, and other related uses. Similar methodology was used across all regions to project other public land. Area change projections were obtained from state, BLM, and other public agency personnel.

[20]Major research studies by region which supported development of these models were: South—Alig (1986) and Alig et al. (1988) analyses of pooled cross-sectional and time series data using seemingly unrelated regression estimation (SURE); West—Park's (1986, 1988a) linear proportions analysis of the allocation of land among forestry, agriculture, and other uses; North Central—Plantinga and others' (1989) cross-sectional analysis of relationships between forest area changes and economic and demographic factors for the Lake States; and Northeast—Howard and Lutz's (1989) SURE analysis of forest area changes for four subregions.

Relationships from these studies, which had land uses and/or forest ownership areas as the dependent variables, were incorporated into a projection system similar to that described by Alig (1985). If a research-based equation for a particular nonforest use was not available, projections of area changes for those uses—crops, pasture/range, urban and other lands—were constructed from expert opinion or existing studies (e.g., urban area projections by the Economic Research Service 1987 and Alig and Healy 1987).

Area Changes in Forest Types

Changes in area among forest types affect both the nature and volume of timber available from forests. For example, decreases in timber production can occur when commercial species are crowded out by noncommercial species. Area change projections by forest management type were based on assumptions about the probability that a particular acre will receive a certain type of management and the associated probabilities that an acre so managed will remain in the same forest type or will make the transition to other forest types.[21]

Projections

The total area of timberland is projected to decrease about 4% between 1987 and 2040 (table 70). During the 1970s, a significant portion of the decline in forest area resulted from conversion of forest to cropland, particularly on southern river bottoms and deltas. However, after 1990, reduction in forest land area will mainly result from conversion to other land uses such as reservoirs, urban expansion, highway and airport construction, and surface mining. Increased reclamation of mined lands in the future will limit the long-run impacts of surface mining on the total area of forest land.

There is always uncertainty associated with projections of land use and, at the present time, the outlook for cropland needs seems especially uncertain. Part of the uncertainty associated with the projections of land use include the implementation of provisions of the Food Security Act of 1985 (Farm Bill). Three major provisions of the 1985 Farm Bill may significantly impact timberland area: (1) the Conservation Reserve Program, (2) the swampbuster and sodbuster provisions, and (3) the conservation compliance provision (Moulton and Dicks 1987).

Over 8 million acres of highly erodible land, primarily in the South, are suitable for afforestation. Under the Conservation Reserve Program of the 1985 Farm Bill, it is assumed that over 3 million acres, mostly in the South, would be planted to trees by 1995. There are 22 million acres of marginal cropland and pasture in the South, including the highly erodible land, that would yield higher rates of return to the owners if they planted pine (USDA FS 1988b). This land, distributed in fairly large acreages across most southern states, would be another source of land for Conservation Reserve or other programs.

Impacts of the "buster" and compliance provisions are more difficult to project because of possible changes in government commodity subsidy and loan programs that would alter the attractiveness of converting erodible land. Next to the Conservation Reserve Program, the conservation compliance provision could have the largest impact on timberland area. Existing cropland identified as highly erodible will be subject to conservation compliance, some of which will be treated under the Conservation Reserve Program.[22] If farmers do not comply, they could lose government subsidies on all acres. However, full implementation and enforcement of provisions of the Farm Bill, such as conservation compliance, will not occur for several years and are difficult to predict. The maximum addition to timberland under the Farm Bill provision would amount to less than 5% of the existing timberland area in the South.

Because of the uncertainty pertaining to future changes in excess agricultural production capacity, it is difficult to project, for example, how timberland with potential for use as cropland or pasture, or the marginal cropland and pasture suitable for pine plantations will be used in the future. In Chapter 8 of this Assessment, alternative futures are simulated to show impacts on the timber resource situation from alternative assumptions about future changes in timberland area.

North.—Projections (table 71) show a slow declining trend in timberland area. The total timberland area in the North drops from about 155 million acres in 1987 to 149 million acres in 2040. The projections show a downward trend in both subregions, but the percentage drop is largest in some northeastern states where substantial relative increases in population and economic activity are expected. In most of the other states the projected changes are small, and in some states the area of timberland is rising or essentially constant in the latter part of the period (Alig et al., in press).

Most of the reduction in timberland area is projected to occur on farms and other private lands, with a slight projected decrease in industry ownership. Public timberland area is projected to increase slightly, by 2%.

Projected area changes for forest types in the North are largely based on a continuation of recent trends. The climax type of maple-beech is projected to increase because of successional forces. Conversely, the area of spruce-fir, oak-hickory, and aspen-birch is projected to drop.

South.—Projections of changes in area shown in table 72 are consistent with those for the recent comprehensive study of the timber supply situation in the South (USDA FS 1988b), except that Kentucky has been added to the 12 Southern states. The resulting projections show a slowly declining trend in total timberland area. The total timberland area in the South declines from about 195 million acres in 1987 to 187 million acres in 2040. The projected reduction is about evenly split between the South Central and Southeast regions.

[21] *Alig (1985) and Alig and Wyant (1985) describe a Markov model for forest types in the Southeast that projects forest types that will result from custodial, harvesting, and other miscellaneous forest management activities. Separate models are constructed for farm, miscellaneous private and industry owner groups. The Markov approaches (e.g., Brooks 1985) are feasible if remeasurement data are available that can be stratified into forest type classes. Probabilities of forest type change are summarized in matrix form. Projections of future forest type areas are calculated by multiplying an initial vector of acres by forest type by the transition probability matrix. If no data on disturbances are available and plots have been remeasured at least once, probabilities are used which represent an average over all disturbance regimes (including no disturbance) and owner groups.*

[22] *The sodbuster and swampbuster provisions of the 1985 Farm Bill alter the attractiveness of converting highly erodible native vegetative rangeland and forest land to crop production and of converting forested wetlands to crop production. If persons break out highly erodible land or convert wetlands for the production of agricultural commodities after December 23, 1985, they lose USDA program benefits on all acres farmed.*

Table 71.—Area of timberland in the North, by ownership and region, specified years 1952–1987, with projections to 2040.

Ownership and region	1952	1962	1970	1977	1987	Projections 2000	2010	2020	2030	2040
					Million acres					
Northeast										
Public	7.3	7.5	7.8	8.2	9.8	10.0	10.1	10.2	10.2	10.2
Forest industry	10.1	10.1	12.2	12.8	12.6	12.5	12.4	12.4	12.3	12.3
Farmer and other pvt.	55.6	60.3	58.0	57.5	57.7	57.6	57.1	55.7	54.6	53.8
Total	73.0	77.9	78.0	78.6	80.1	80.1	79.6	78.2	77.1	76.3
North Central										
Public	23.0	21.9	21.7	21.2	21.2	21.2	21.2	21.2	21.3	21.3
Forest industry	3.6	3.6	5.0	4.7	4.4	4.4	4.4	4.5	4.5	4.5
Farmer and other pvt.	54.7	53.3	49.7	49.0	49.0	48.7	48.3	47.8	47.6	47.4
Total	81.2	78.7	76.3	74.9	74.6	74.3	73.9	73.5	73.3	73.2
Total North										
Public	30.2	29.4	29.5	29.4	30.9	31.1	31.3	31.4	31.5	31.5
Forest industry	13.7	13.7	17.2	17.5	17.0	16.9	16.9	16.8	16.8	16.7
Farmer and other pvt.	110.3	113.5	107.7	106.6	106.7	106.3	105.4	103.5	102.2	101.2
Total	154.3	156.6	154.4	153.4	154.6	154.4	153.6	151.7	150.5	149.5

Note: Data for 1952 and 1962 are as of December 31; all other years are as of January 1. The same regions as in Chapter 3 are used. Data may not add to totals because of rounding.
Source: Waddell et al. 1989.

Table 72.—Area of timberland in the South, by ownership and region, specified years 1952–1987, with projections to 2040.

Ownership and region	1952	1962	1970	1977	1987	Projections 2000	2010	2020	2030	2040
					Million acres					
Southeast										
Public	8.0	8.3	8.2	8.5	8.8	8.8	8.9	8.9	8.9	8.9
Forest industry	13.9	14.8	15.6	15.3	16.8	17.0	17.0	17.0	17.0	17.0
Farmer and other pvt.	67.1	67.9	66.2	64.0	59.0	56.4	55.9	55.2	54.7	54.4
Total	89.1	91.0	90.0	87.8	84.6	82.2	81.7	81.1	80.6	80.3
South Central										
Public	9.7	9.7	10.2	10.1	10.9	11.2	11.4	11.5	11.6	11.7
Forest industry	17.9	18.8	20.3	21.5	21.4	21.7	21.9	22.0	22.1	22.2
Farmer and other pvt.	87.9	89.1	82.8	78.9	78.4	76.1	75.0	74.0	73.2	72.7
Total	115.5	117.7	113.3	110.6	110.8	109.1	108.2	107.5	106.9	106.6
Total South										
Public	17.7	18.0	18.4	18.6	19.7	20.1	20.3	20.4	20.5	20.5
Forest industry	31.8	33.6	35.9	36.9	38.2	38.8	38.9	39.0	39.1	39.2
Farmer and other pvt.	155.1	157.0	149.0	142.9	137.5	132.4	130.9	129.2	127.8	127.1
Total	204.5	208.7	203.3	198.4	195.4	191.3	190.0	188.6	187.4	186.8

Note: Data for 1952 and 1962 are as of December 31; all other years are as of January 1. Includes Kentucky in addition to the 12 states examined in the South's Fourth Forest Report (USDA FS 1988b). Data may not add to totals because of rounding.
Source: Waddell et al. 1989.

In some states, particularly in the east Gulf area, where substantial relative increases in population and economic activity are expected, the drop is fairly large. In most of the other states the projected changes are small, and in some states the area of timberland is rising or essentially constant in the latter part of the period.

The projected net area changes reflect the direct conversion of timberland to urban and developed uses, and other timberland acres converted to replace cropland lost to urban and developed uses. A small reduction for crop area is projected, while urban and related uses go up about 25%. Pasture and range area is projected to drop slightly.

Private owners control approximately 90% of the South's timberland and this is projected to continue. Area changes among the major groups of private owners have been substantial. Around 18 million acres or 11% of the area in farmer and other private ownership has been converted to other uses or transferred to other owners since 1952. Most of this area reduction has occurred on farmer ownerships.

Farmer ownership of timberland has declined because of several reasons. Many owners of timberland who were farm operators sold or passed on their holdings to new owners, who were classified as other private owners since they did not secure their primary source of income from farming. In addition, many farmers increasingly secured their livelihood off farms and were subsequently classified as other private owners. Conversion to other uses, primarily agriculture, has also contributed to a reduction in farm forest area.

Timberland area in farmer ownership is projected to continue declining. This trend is consistent across the South and in line with historical trends. However, over 3 million acres of highly erodible cropland under the Conservation Reserve Program of the 1985 Farm Bill could be planted to trees on farm ownerships by 1995, but this would still not be enough overall to offset forest area reductions.

Other individual and corporate private owners have acquired many of the timberland acres that were once owned by farmers. Corporate ownership is projected to increase in size, partly due to investment in southern pine timberland (USDA FS 1988b). It is uncertain how these corporate lands will be managed in the future. It remains to be seen whether some corporate owners will divest of timberland after harvest of the current rotation's crop, or if they will invest in long-run timberland management. Individual owners, the other component of the miscellaneous private ownership group, are the largest ownership class. This diverse set of owners holds over one-third of the southern timberland base—almost four times as much as corporate owners. Unlike the corporate owners, individuals in the other private owner group are projected to reduce their holdings of timberland in the future.

Forest industry has steadily acquired timberland in the South since 1952. In 1987, industry owned 38 million acres of timberland in the South, 6 million acres more than in 1952. The trend in forest industry area has been upward across all the southern states. In the past, many forest products companies have found it advantageous to own large amounts of timberland (Clephane 1978). Some of the recognized advantages include an assured wood supply for mills that represent large investments, augmentation of supplies of low-cost timber, an inflationary hedge, and certain tax advantages. In addition, some banks have required certain levels of timberland to be owned as one condition for loans.

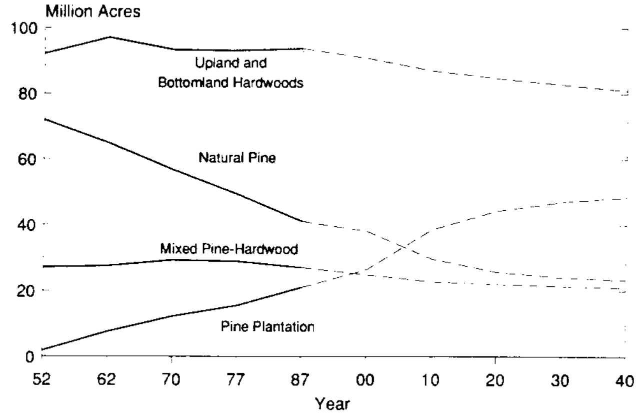


Figure 54.—Timberland area in the South, by forest management type, 1952–1987, with projections to 2040.

Although recent data do not show a significant slackening in the acquisition of timberland by industry, several factors now seem to be operating that reduce the attractiveness of industrial ownership of timberland. These include cash flow considerations, other investment opportunities, opportunities for land leasing and long-term harvesting rights, and the increased substitution of more intensive forestry practices in place of land acquisition.

Given this current setting, it has been assumed that the area in forest industry ownership will increase at a slower rate than in the past. Forest industries are projected to add around one million acres over the next 45 years. This represents a 3% increase. Most of the acquired land is expected to be in the South Central Region.

Public ownership of timberland in the South represents only about 10% of the total timberland base. Public ownership of timberland is projected to increase slightly, by 0.8 million acres or 4%, by 2040. Not included in the other public timberland expansion is some bottomland hardwood acreage that is likely to be acquired by state agencies and withdrawn from the timberland base to protect nontimber forest resources.

Projected changes in the area of the forest management types are consistent with recent historical trends. The largest area changes are projected for the pine types in the South (fig. 54). The area in pine plantations is projected to increase by over 25 million acres, thereby doubling by 2040 (USDA FS 1988b).

In contrast, natural pine area is projected to drop by nearly half. The net change in southern pine area is an increase of approximately 10 million acres by 2040. The projected doubling of planted pine area is largely due to the addition of pine plantations on forest industry lands. With management intensification on these industrial lands, many harvested natural pine stands are being artificially regenerated. This conversion to planted pine allows genetically improved stock to be introduced on many acres and trees to be spaced so as to reduce future management costs.

The projected drop in natural pine area is also due to an assumed continuation of trends in substantial hardwood encroachment after harvest of pine stands on the lands in farmer and other private ownerships. The farmer and other private ownerships contain the bulk of the natural pine area, and the projections assume that current trends in reforestation (Fecso et al. 1982) will largely continue.

The Rocky Mountains and Great Plains.—Projections show a slowly declining trend (table 73) as total timberland area in the Rocky Mountains and Great Plains drops from about 61 million acres in 1987 to 59 million acres in 2040. The projected decrease occurs largely on public lands and on farmer and other private ownerships. Overall, area changes among uses are relatively small compared to other regions.

The projected net area changes largely reflect withdrawals of public timberland, the direct conversion of timberland to urban and developed uses, and other acres converted to replace cropland lost to urban and developed uses. The area of cropland is projected to drop by several million acres, while urban and related uses go up slightly. The pasture and range area is projected to increase by several million acres, as a result of the conversion of erodible cropland to grassland through the Conservation Reserve Program.

Only small relative changes in area of softwood and hardwood forest types are projected for this region by 2040. Softwood types cover most of the timberland base and are projected to maintain that dominance.

Pacific Coast.—Timberland area in the Pacific Coast is projected to drop by 5 million acres, or 7%, by 2040 (table 74). As in the Rocky Mountains and Great Plains, most of the projected reduction is for the public and farmer and other private ownerships. Much of the current timberland in the Pacific Coast Region is located on lands where forestry has a comparative advantage or is a residual use due to physiography, and projected changes are smaller than historical ones.

The projected net area changes largely reflect withdrawals on public lands and direct conversion of timberland to urban and developed uses and other acres converted to replace cropland lost to urban and developed uses. Public timberland area is projected to drop 6%, largely due to withdrawals.

Currently, industry owns approximately 17% of the Pacific Coast timberland, up from the 13% share in 1952. This share is projected to change little, rising to 18% by 2040.

Around 3 million acres or 17% of the area in farmer and other private ownership was converted to other uses or transferred to other owners between 1952 and 1977. Most of this area reduction occurred on farmer ownerships. Since 1977, around 6 million acres of timberland were transferred from public ownership to the farmer and other private ownership in Alaska, resulting in an overall increase of over 4 million acres for the farmer and other private class in the Pacific Coast section between 1977 and 1987. Future acreage transfers between ownerships are expected to be much smaller, with total timberland area on the farmer and other private ownership projected to drop 11% by 2040.

Alaska contains 119 million acres of forest land, about one-sixth of that in the United States. However, only 15.8 million acres, some 13% of the state total, is classified as timberland. Of this area, some 10.1 million acres is in coastal Alaska. The remaining 5.7 million

Table 73.—Area of timberland in the Rocky Mountains and Great Plains, by ownership and region, specified years 1952–1987, with projections to 2040.

						Projections				
Ownership and region	**1952**	**1962**	**1970**	**1977**	**1987**	**2000**	**2010**	**2020**	**2030**	**2040**
					Million acres					
Great Plains										
Public	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2
Forest industry	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Farmer and other pvt.	2.6	2.5	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.2
Total	4.1	3.8	3.8	3.7	3.5	3.4	3.5	3.5	3.5	3.5
Rocky Mountains										
Public	48.1	48.7	46.4	42.1	42.9	41.9	41.9	41.9	41.9	41.9
Forest industry	2.2	2.2	2.2	2.1	2.9	2.9	2.9	2.9	2.9	2.9
Farmer and other pvt.	12.3	12.2	12.2	12.3	11.8	11.5	11.4	11.2	11.1	10.9
Total	62.6	63.1	60.8	56.5	57.6	56.4	56.2	56.1	55.9	55.7
Total Great Plains & Rocky Mountains										
Public	49.5	50.0	47.7	43.5	44.1	43.1	43.1	43.1	43.1	43.1
Forest industry	2.2	2.2	2.2	2.1	3.0	3.0	3.0	3.0	3.0	3.0
Farmer and other pvt.	14.9	14.7	14.6	14.6	14.0	13.8	13.6	13.5	13.3	13.2
Total	66.6	66.9	64.5	60.2	61.1	59.9	59.7	59.5	59.4	59.3

Note: Data for 1952 and 1962 are as of December 31; all other years are as of January 1. Includes the States of North Dakota, South Dakota, Nebraska, and Kansas, in addition to the Rocky Mountain States, as in Chapter 3. Data may not add to totals because of rounding.

Source: Waddell et al. 1989.

Table 74.—Area of timberland in the Pacific Coast, by ownership and region, specified years 1952–1987, with projections to 2040.

Ownership and region	1952	1962	1970	1977	1987	Projections 2000	2010	2020	2030	2040
	Million acres									
Pacific Northwest										
Douglas-fir subregion										
Public	12.1	12.1	11.9	11.4	11.3	11.0	11.0	10.9	10.9	10.8
Forest industry	6.9	7.2	7.2	7.5	7.3	7.6	7.7	7.7	7.7	7.6
Farmer and other pvt.	6.3	5.8	5.5	4.5	4.6	4.1	3.9	3.8	3.6	3.6
Total	25.2	25.1	24.6	23.4	23.1	22.8	22.6	22.4	22.2	22.0
Ponderosa pine subregion										
Public	13.6	13.2	13.1	12.9	11.1	10.6	10.6	10.5	10.4	10.2
Forest industry	2.2	2.2	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3
Farmer and other pvt.	3.9	4.0	3.6	3.4	2.3	2.3	2.2	2.2	2.2	2.2
Total	19.6	19.4	19.1	18.7	15.8	15.3	15.1	15.0	14.9	14.7
Alaska										
Public	20.2	19.8	19.7	19.3	9.6	9.2	9.1	9.0	9.0	9.0
Forest industry	0	0	0	0	0	0	0	0	0	0
Farmer and other pvt.	.2	.3	.3	.5	6.2	6.5	6.6	6.7	6.7	6.7
Total	20.3	20.1	20.0	19.7	15.8	15.8	15.8	15.7	15.7	15.7
Pacific Southwest										
Public	9.6	9.9	9.9	9.1	9.6	9.1	9.0	9.0	9.0	8.9
Forest industry	2.2	2.4	2.7	2.7	2.8	2.8	2.7	2.6	2.4	2.2
Farmer and other pvt.	6.5	5.9	5.5	5.4	5.1	4.5	4.2	4.0	3.8	3.5
Total	18.2	18.3	18.0	17.3	17.4	16.4	16.0	15.5	15.1	14.7
Total Pacific Coast										
Public	55.4	55.1	54.6	52.7	41.6	40.0	39.7	39.5	39.2	39.0
Forest industry	11.2	11.9	12.3	12.5	12.5	12.8	12.8	12.6	12.4	12.1
Farmer and other pvt.	16.8	15.9	14.9	13.9	18.1	17.4	17.0	16.7	16.3	16.1
Total	83.4	82.9	81.8	79.1	72.1	70.2	69.5	68.7	68.0	67.1

Note: Data for 1952 and 1962 are as of December 31; all other years are as of January 1. Hawaii is included in the Pacific Southwest. Data may not add to totals because of rounding.
Source: Waddell et al. 1989.

acres are in the Alaska interior. Projections of changes in total timberland area in Alaska indicate an essentially constant base between 1987 and 2040. Forest industry ownership is expected to remain negligible, although in time, part of the land transferred to Alaskan Natives may be sold to forest industries.

Projected area changes for forest types in the Pacific Coast section are relatively small. The most substantial changes are projected to occur on forest industry lands as more acres are planted to Douglas-fir. Conversely, hardwood (alder) area on this ownership is projected to decline.

Projected timberland losses on farmer and miscellaneous private lands are distributed across all forest types. This is also the case for other public lands. Projected overall changes in forest type areas are small for the public ownerships.

Pulpwood Supply

Regional pulpwood supply functions in the FPL Pulpwood Model were based on unit price elasticity assumptions, with supply quantities projected to increase at a rate corresponding to the projected regional growth in timber inventories. Projections of actual pulpwood consumption derived from the FPL Pulpwood Model were then used to make quantitative adjustments to timber supply in the TAMM/ATLAS model, with projected pulpwood requirements satisfied partly by projected supplies of wood residues from the solid-wood product sector and partly by timber harvest.

Adjustments for Timber Removals

Estimates of timber harvest (also called roundwood supplies) include removals from several different sources. The most important removals (in an inventory accounting sense) are those from growing stock sources. These include: (1) harvest of roundwood products such as sawlogs, veneer logs and pulpwood from growing stock and sawtimber, (2) logging residues, and (3) other removals resulting from noncommercial thinnings, changes in land use such as clearing for cropland, highways or housing developments, and withdrawal of commercial timberland for parks, wildernesses, and other nontimber uses.

The projected supplies (harvest) of roundwood products are internally generated in the forest sector model. The determination of timber removals is accomplished by adjusting the projected timber harvest for removals from nongrowing stock sources and than adding the other components of removals—logging residues and other removals. The result is an estimate of the timber removed from growing stock inventory. The data for these three adjustments are derived from the timber product output tables (tables 30–32) given in Waddell et al. 1989.

Logging Residues

Logging residues have always been an important component of timber removals, although they have been declining as a percentage of the total. Between 1952 and 1986, for example, softwood logging residues dropped from about 9.8% of product removals from growing stock—roundwood products plus logging residues—to 9.0%; and hardwood residues fell from 22.2% to 13.2% (table 75). These declines largely reflect the effects of rising stumpage prices that have made it economical to remove more of the lower quality material that previously was left as logging residues. Technological innovations such as in-woods chipping and rapid growth in the demand for wood in the pulp industry and for industrial fuelwood have also contributed to the increased utilization.

In the east, softwood logging residues as a percentage of product removals from growing stock are roughly half of those in the Pacific Coast regions. In the Pacific Coast states, softwood logging residues were 12.6% of product removals in 1986, the highest in the country. Total hardwood logging residues, more than 13% of product removals, compose a much larger percentage of product removals than for softwoods. This reflects limited markets for much of the low-quality material in the hardwood inventory.

For the projection period, it has been assumed that logging residues from both hardwoods and softwoods will decline as a percent of product removals from growing stock in regions with relatively high current proportions. Major factors in these declines are the expected increases in stumpage prices and intensified competition for wood fiber. This will result in increased use of small stems, chunks, and low-quality stems for fuelwood and pulpwood. Increased tree-length logging and in-woods chipping of pulpwood and fuelwood will reduce residual formation. Another factor is anticipated improvements in felling and bucking practices. The decline in the harvest of old growth timber in the West and increased use of hardwoods for pulping and as fuelwood are also expected to contribute to the improved utilization.

Other Removals

That part of timber removals classified as other removals is composed of (1) losses from timber inventories resulting from the diversion of timberland to other uses such as crop or pasture land, roads, urban areas, parks and wilderness; and (2) timber removed in cultural operations such as noncommercial thinning.

The historical data on other removals are estimates of actual volumes for the indicated years (USDA FS 1982, Waddell et al. 1989). They do not include the removals associated with the diversion of timberland, such as withdrawals for wilderness that do not take place on a regular and continuing basis. Such land diversions are included in the projections. Thus, and as a result of expected withdrawals for wilderness in the 1990s, other removals in 1990 are substantially above the historical

Table 75.—Logging residues as a percent of timber product removals from growing stock in the United States, by softwoods and hardwoods and section, specified years 1952–1986, with projections to 2040.

						Projections				
Species group and section	**1952**	**1962**	**1970**	**1976**	**1986**	**2000**	**2010**	**2020**	**2030**	**2040**
					Percent					
Softwoods										
North	11.5	11.0	10.8	11.0	4.6	4.5	4.5	4.5	4.5	4.5
South	6.6	6.3	6.9	5.9	6.7	6.5	6.4	6.3	6.1	6.0
Rocky Mountain	10.9	10.9	11.1	11.0	10.8	10.8	10.7	10.6	10.5	10.4
Pacific Coast[1]	12.2	11.7	12.5	10.2	12.6	12.2	11.9	11.6	11.3	11.0
United States	9.8	9.6	10.0	8.4	9.0	8.9	8.8	8.6	8.4	8.2
Hardwoods										
North	15.8	15.3	15.2	17.2	9.9	9.0	8.7	8.5	8.5	8.5
South	25.9	24.4	22.6	16.6	15.6	15.5	15.3	15.2	15.1	15.0
Rocky Mountain	([2])	([2])	([2])	25.0	19.7	24.0	23.0	22.0	21.0	20.0
Pacific Coast[1]	28.6	26.0	27.4	25.2	7.2	7.4	7.6	7.7	7.8	8.0
United States	22.2	20.7	19.7	17.1	13.2	12.7	12.5	12.3	12.3	12.2

[1]*Includes Alaska.*
[2]*Hardwood timber harvests are too small for accurate estimation of logging residues.*

volumes. After 1990, the major withdrawals for wilderness were assumed to be over and other removals decline in line with the assumed reductions in timberland areas.

Timber Supplies from Nongrowing Stock Sources

Projected timber supplies comes primarily from growing stock inventories. Part of the supplies, however, come from salvable dead trees, rough and rotten trees, tops and limbs, defective sections of growing stock trees in urban areas, fence rows and on forested lands other than timberland. Output of timber products from nongrowing stock sources is influenced by markets for pulpwood and fuelwood.

The proportion of roundwood supply originating from softwood nongrowing stock sources dropped between 1952 and 1976 (table 76). The hardwood supply showed a similar trend until the 1970s and then turned up slightly in the last assessment. Timber product output from nongrowing stock sources rose from 6.9 in 1976 to 11.5% in 1986 for softwoods, and from 14.0% in 1976 to 38.5% in 1986 for hardwoods. These changes are almost entirely explained by the rapid increase in the use of fuelwood during the past decade.

Among the major geographic sections, there are some trends that differ noticeably from the general U.S. trends. Old-growth forests on the Pacific Coast and in the Rockies contain large volumes of salvable dead timber. With high demand for stumpage, and increasing use of lower quality materials for chips and fuelwood, the proportion of softwood timber supplies coming from nongrowing stock sources on the Pacific Coast is expected to remain high relative to the South.

In the Rocky Mountains, nongrowing stock sources provided 4.5% of the softwood supply in 1976. By 1986, this had risen to 11.9%. This is assumed to increase

Weighing lodgepole pine bole sections to determine volumes of useable material.

Table 76.—Timber product output from nongrowing stock sources as a percent of timber supplies in the United States, by softwoods and hardwoods and section, specified years 1952–1986, with projections to 2040.

Species group and section	1952	1962	1970	1976	1986	Projections 2000	2010	2020	2030	2040
					Percent					
Softwoods										
North	13.3	12.6	12.6	12.6	27.4	30.0	30.0	30.0	30.0	30.0
South	8.4	8.7	4.5	5.0	4.0	4.0	4.0	4.0	4.0	4.0
Rocky Mountain	5.8	5.6	4.7	4.5	11.9	12.0	12.0	12.0	12.0	12.0
Pacific Coast[1]	12.4	11.6	8.9	8.6	17.4	17.7	18.0	18.3	18.6	18.9
United States	10.4	10.0	7.0	6.9	11.5	11.8	12.0	12.1	12.2	12.3
Hardwoods										
North	23.5	17.7	11.9	16.5	51.8	53.0	54.0	55.0	55.0	55.0
South	19.0	18.9	13.9	11.9	21.9	23.0	23.5	24.0	24.5	25.0
Rocky Mountains	([2])	([2])	([2])	([2])	79.7	80.0	80.0	80.0	80.0	80.0
Pacific Coast[1]	14.3	11.5	6.1	11.3	46.2	48.4	50.1	51.7	53.3	54.9
United States	20.9	18.5	13.9	14.0	38.5	40.1	40.9	41.7	41.9	42.2

[1] *Includes Alaska.*
[2] *Hardwood timber harvests are too small for accurate estimations of output originating from nongrowing stock sources.*

through the rest of the projection period as fuelwood continues to be an important product.

Nongrowing stock sources provided about 12.6% of the softwood timber supplies in the North in 1976. This increased to 27.4% in 1986, and is expected to increase further as fuelwood consumption continues to increase. The proportion of softwood nongrowing stock output in the South is low—5.0% in 1976 and 4.0% in 1986. This is expected to remain constant over the next five decades.

Hardwood forests contain large volumes of rough and rotten trees and tops and branches. Hardwoods also make up most of the urban forest, fence rows, and other similar sources of nongrowing stock timber supplies. As a result, a substantial fraction of hardwood roundwood supplies, 38.5% in 1986, have come from nongrowing stock sources.

With increasing demand for fuelwood and improvements in techniques for harvesting and processing hardwood for pulp and paper, nongrowing stock is expected to continue to be an important and, in most regions, a growing part of hardwood timber supplies. In the North, for example, the proportion of hardwood timber supplies originating from nongrowing stock rises from 51.8% in 1986 to 55.0% in 2040.

National Forest Harvest Levels

One of the major determinants of future timber supplies are the assumptions concerning national forest harvest levels. These assumptions were derived from both ongoing planning efforts and budget submissions and represent a continuation of recent trends in harvest.

Historical levels of total national forest softwood harvest are shown in the left portion of figure 55 and in table 77. Following World War II, strong demand for forest products and declining private harvests brought ex-

Table 77.—Softwood harvest and growing stock inventory for the national forests ownership, specified years 1952–1986, with projections to 2040.

Item and region	1952	1962	1970	1976	1986	2000	2010	2020	2030	2040
					Million cubic feet					
Northeast										
Standing inventory	459	532	637	636	746	911	999	1,053	1,113	1,085
Harvest	3	3	3	2	6	7	10	12	13	14
North Central										
Standing inventory	1,336	1,988	2,170	2,542	3,270	3,723	3,885	3,963	4,081	3,846
Harvest	24	28	34	32	29	49	53	58	63	67
Southeast										
Standing inventory	1,991	2,152	2,596	2,824	2,855	3,156	3,516	3,864	4,362	4,876
Harvest	14	27	33	61	59	56	64	66	68	70
South Central										
Standing inventory	3,123	4,874	4,952	5,670	6,466	6,822	7,270	7,647	8,387	9,146
Harvest	141	90	147	174	163	185	209	216	223	229
Rocky Mountain[1]										
Standing inventory	58,013	62,979	63,825	65,081	70,832	70,929	70,953	71,293	71,872	72,552
Harvest	218	387	480	426	465	603	642	669	695	722
PSW[2]										
Standing inventory	29,590	29,391	28,694	28,073	27,213	26,257	26,486	26,786	27,346	27,710
Harvest	89	216	346	286	347	296	299	304	309	314
PNW West										
Standing inventory	47,584	47,704	45,478	44,088	33,607	28,993	27,029	25,924	25,342	25,133
Harvest	361	586	489	511	659	562	578	577	577	576
PNW East										
Standing inventory	23,408	25,757	25,911	23,649	17,331	14,624	13,334	12,333	11,689	11,457
Harvest	100	232	286	292	378	316	325	324	324	323
Alaska[3]										
Standing inventory	38,850	38,228	37,555	35,414	6,853	6,027	5,448	5,141	5,162	5,672
Harvest	11	66	100	83	47	83	83	85	86	89
United States Total										
Standing inventory	204,354	213,605	211,818	207,977	169,173	161,144	158,921	158,004	159,355	161,477
Harvest	961	1,635	1,918	1,867	2,153	2,157	2,263	2,311	2,357	2,404

[1]*Rocky Mountains region historical data includes the Great Plain states.*
[2]*PSW exludes Hawaii.*
[3]*Figures for Alaska have been revised since publication of Waddell et al. 1989.*
Note: Inventory data for 1952 and 1962 are as of December 31. Inventory data for 1970 and projection years are as of January 1. Inventory data for 1976 and 1986 are as of January 1 of the following year.
Sources: For historical data: USDA FS 1982, Waddell et al. 1989.

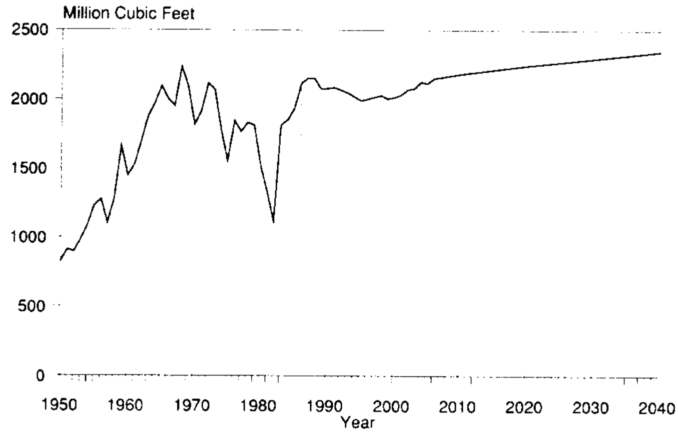


Figure 55.—Total national forest softwood timber harvest.

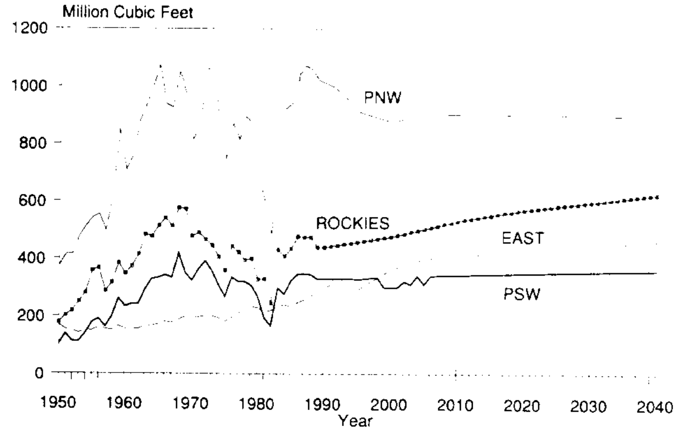


Figure 56.—National forest softwood harvest by region.

panded markets for national forest timber. The USDA Forest Service shifted from its "custodial" management posture of the inter-war years toward a more active policy of timber sales. Harvest grew rapidly as a result. By the late 1960s, cut was approaching sustainable levels under existing management plans in some areas of the West, and an array of new management priorities brought significant changes in USDA Forest Service supply policies. Volume-based methods of harvest scheduling were supplanted, first in 1973 by a nondeclining flow policy, and then in 1976 by the National Forest Management Act (NFMA). As part of NFMA, the Forest Service was required to develop 10-year interdisciplinary forest plans for each administrative unit in the National Forest System. Substantial areas of land were redesignated as wilderness or undeveloped reserves and removed from the allowable cut base. In unreserved areas, harvest planning and practices were modified to minimize adverse environmental impacts and deleterious effects on noncommodity uses of the forest. The consequence of these and other actions has been a stabilization (or in some cases a gradual decline) in harvest over the past 20 years.

The second bulge in national forest harvest (1985–88) reflects a one-time drawdown of uncut volume accumulated during the 1981–82 recession and higher harvesting rates of recent sales. The level of Forest Service timber offered for sale has remained relatively unchanged during the 1980s, ranging from a high of 12.2 billion board feet in 1981 to a low of 11.1 billion board feet in 1982. It was 11.4 billion board feet in (fiscal year) 1988.

Differences in regional patterns of national forest harvest, illustrated in the left portion of figure 56, are a reflection of varying rates of regional industrial development and conditions of the national forest timber resource. The national pattern of figure 56 is derived from the nearly parallel movements of cut in the largest producing areas: the Pacific Northwest, Rocky Mountain, and California regions. In the wake of rapid industrial expansion and harvest in earlier periods, all of these regions faced significant reductions in private supply during the 1950s and 1960s. Large volumes of mature timber, reasonable wood costs, and an expansive supply policy were ample stimuli for increased national forest harvest. Harvest limitations since the mid-1960s have been most pronounced in these regions. Harvest patterns in the East are dominated by the Southern states, where private timber supply and output of the solidwood products industry underwent a major contraction during the 1950s and early 1960s. The reduction in timber demand was sufficient to stabilize national forest harvest as well. With the revival of the industry in the mid-1960s, harvests from the national forests have increased in line with expanding growth and inventory.

The right hand portions of figure 55 and table 77 illustrate the projections of total national forest softwood harvest in the United States. The projections of national forest hardwood harvest is shown in table 78. These harvest levels were derived from projections of allowable sale quantity (plus projections of the nonchargeable harvest). Harvests from national forest lands are assumed to be at the level consistent with the sum of preferred alternatives in forest plans for 2000 and beyond. Harvests for the years 1988–1995 are estimated by the Forest Service timber management staff. For the years 1996–1999, harvests are estimated as a linear extrapolation between 1995 and 2000.

Softwood national forest harvest rises from approximately 2.15 billion cubic feet at present to about 2.40 billion cubic feet by 2040. In effect, these projections change the experience of the last several decades when national forest harvests have been relatively flat. Most of this growth in harvest comes in the East and in the Rockies—particularly in the Northern Region. For hardwoods, the trend in Forest Service harvest is for modest growth. Unlike softwoods, the Forest Service is not a major supplier of hardwood stumpage nor is that expected to change in the future.

Regional projections of the softwood harvest are illustrated in the right hand portion of figure 56. Compared to historical levels, this projected harvest pattern would involve significant changes in the relative importance of various regions in total national forest harvest. Supply in the Pacific Coast regions declines from current levels but remains relatively stable after 2000. In contrast, national forest harvest in the Rocky Mountain regions rises throughout the projection period. Timber

Table 78.—Hardwood harvest and growing stock inventory for the national forests ownership, specified years 1952–1986, with projections to 2040.

Item and region	1952	1962	1970	1976	1986	2000	2010	2020	2030	2040
					Million cubic feet					
Northeast										
Standing inventory	1,983	2,580	3,007	3,749	4,127	4,242	4,224	4,178	4,106	4,070
Harvest	9	9	15	21	26	36	37	38	40	20
North Central										
Standing inventory	2,482	3,491	3,994	4,483	5,470	5,868	5,887	5,810	5,640	5,250
Harvest	32	34	40	43	76	99	104	109	114	119
Southeast										
Standing inventory	2,481	2,979	3,511	4,156	5,055	5,125	5,160	5,199	5,344	5,432
Harvest	9	11	17	15	14	16	20	23	26	29
South Central										
Standing inventory	1,785	2,793	3,010	3,576	4,502	4,591	4,548	4,497	4,689	4,740
Harvest	41	29	32	18	35	53	63	73	83	93
West[2,3]										
Standing inventory	4,522	5,008	5,262	5,080	5,558	156	164	173	183	194
Harvest	10	14	19	4	16	([1])	([1])	([1])	([1])	([1]
United States total										
Standing inventory	13,253	16,851	18,784	21,044	24,712	19,982	19,983	19,858	19,962	19,686
Harvest	101	97	123	101	166	204	224	243	262	260

[1]*Hardwood projections for the western national forests are incomplete.*
[2]*West excludes Hawaii.*
[3]*West projections 2000–2040 are for Alaska only (no data available for other regions).*
Note: See table 77.
Source: See table 77.

harvest from eastern national forests is projected to exceed the Pacific Southwest after 2000.

Other Public Harvest Levels

The smallest ownerships in terms of timber harvest are the various other public ownerships. These ownerships include a diverse collection of different land owners such as the Department of Defense, many counties and states, and the Bureau of Land Management. Historical and projected roundwood supplies, net annual growth, and growing stock inventories are shown in table 79 for softwoods and table 80 for hardwoods. The historical data for 1952–76 was extracted from similar tables in the last Assessment. The data for 1986 was compiled from various material in Waddell et al. 1989. The regional definitions in both tables for 1986 differ from the historical data as described in Chapter 3. The projections were taken from several sources.[23]

Both softwood and hardwood other public inventories are expected to continue increasing during the next five decades. The hardwood inventories increase at a somewhat faster rate than do the softwoods inventories. Only towards the end of the projection period do harvest and growth come into balance for both hardwoods and softwoods. Net growth especially for hardwoods is expected to drop as stands mature and growth rates drop. The largest drops in hardwood growth are expected in the next 15 years.

[23]*The projections in tables 79 and 80 have been revised from similar projections prepared as part of the Fourth Forest (USDA FS 1988b) for the South and for the other regions as part of the last Assessment by first comparing the actual data for 1986 with the projected values for 1986. In the next step, harvest projections from the past studies were judgmentally adjusted by the ratio of projected to actual harvest for 1986. The growth projections were retained from the last Assessment and the value for 2040 was computed as the continuation of the trend between 2000 and 2030. Inventory levels were computed for all projections using a growth-drain identity.*

PROJECTED TRENDS IN PROCESSING COSTS

In addition to timber products demand, the timber resource situation is also influenced by the projected trends in timber processing costs. Timber processing is the conversion of the timber resource into the wood products demanded by consumers.

Processing costs are the costs of converting timber into wood products and generally include labor, energy, and equipment costs. Income offsets from the sale of byproducts, such as wood residues in the production of lumber, are not included. Processing costs do not include the cost of stumpage. The following projected trends in processing costs assume that future technological development and adoption will offset increases in labor, energy, and capital costs.

Logging

Logging involves tree felling, bucking the trees into logs, skidding or yarding the logs to a landing, and loading and hauling them to processing facilities. Timber

Table 79.—Softwood roundwood supplies, net annual growth, and growing stock inventory for other public ownerships, specified years 1952–1986, with projections to 2040.

Item and region	1952	1962	1970	1976	1986	2000	2010	2020	2030	2040
					Million cubic feet					
Northeast										
Roundwood supplies	7	5	7	13	18	25	29	32	35	37
Net annual growth	27	32	37	49	54	57	57	57	56	55
Inventory	885	1,044	1,275	1,555	2,428	3,002	3,392	3,752	4,092	4,412
North Central										
Roundwood supplies	33	35	38	41	43	76	108	110	110	110
Net annual growth	92	120	126	142	168	149	148	149	152	157
Inventory	2,162	2,943	3,237	3,728	4,840	6,240	7,040	7,810	8,590	9,410
Southeast										
Roundwood supplies	51	43	69	88	100	130	134	139	144	144
Net annual growth	70	84	126	149	159	155	162	174	188	188
Inventory	1,506	1,996	2,176	2,648	3,288	3,524	3,724	3,997	4,342	5,015
South Central										
Roundwood supplies	30	30	32	51	64	60	60	60	60	60
Net annual growth	56	58	78	71	55	55	58	65	91	91
Inventory	780	824	1,225	1,340	1,458	1,326	1,223	1,179	1,148	1,127
Rocky Mountains[1]										
Roundwood supplies	72	78	78	85	79	79	78	78	78	78
Net annual growth	119	141	162	162	220	193	171	169	173	183
Inventory	9,923	10,147	10,399	10,429	11,094	12,732	13,702	14,652	15,642	16,732
Pacific Southwest[2]										
Roundwood supplies	3	16	26	22	12	39	41	43	43	43
Net annual growth	14	14	14	14	25	23	25	27	30	33
Inventory	1,892	1,435	1,150	1,108	1,245	1,385	1,215	1,046	906	796
Douglas-fir subregion										
Roundwood supplies	158	290	343	428	418	450	450	450	450	450
Net annual growth	193	316	356	371	495	458	516	606	710	685
Inventory	20,085	19,787	19,610	19,161	19,576	16,748	17,047	17,934	19,754	21,887
Ponderosa pine subregion										
Roundwood supplies	48	61	97	89	77	111	135	138	141	145
Net annual growth	66	88	91	96	139	129	136	145	155	166
Inventory	7,792	6,536	6,483	6,748	7,027	7,067	6,849	6,564	6,198	5,728
Alaska[3]										
Roundwood supplies	1	4	12	5	3	4	5	6	6	7
Net annual growth	93	107	123	137	56	79	64	44	33	26
Inventory	10,173	11,021	11,864	12,334	5,766	6,851	8,001	8,662	8,949	9,143
United States										
Roundwood supplies	403	561	702	822	814	974	1,040	1,056	1,067	1,073
Net annual growth	730	961	1,113	1,191	1,371	1,298	1,337	1,436	1,588	1,584
Inventory	55,198	55,733	57,419	59,051	56,722	58,875	62,193	65,596	69,621	74,249

[1]*Rocky Mountains region historical data (excluding roundwood supply) includes the Great Plain states.*
[2]*PSW exludes Hawaii.*
[3]*Figures for Alaska have been revised since publication of Waddell et al. 1989.*
Note: See table 77.
Source: See table 77.

stand characteristics influencing logging cost include stand diameter, stand volume, and the steepness of the terrain. Historical data and projections are shown in table 81. The higher logging costs in the Rocky Mountains and Pacific Coast are due to a combination of steeper terrain and higher labor costs. Between 1952 and 1985, logging costs increased in all sections and regions. Increases in energy, labor, and equipment costs accounted for part of this increase. The increase in logging costs in the Rocky Mountains and Pacific Coast sections was also attributable to declining stand diameter and volume as well as the harvesting of stands on steeper terrain.

Logging costs are projected to increase at a faster rate than that experienced from 1952 to 1985 (Bradley, in press). The rate of increase in logging costs is the slowest in the Pacific Coast Region, with increases of 45%, 54%, and 49% projected for the Pacific Northwest-West, Pacific Northwest-East, and Pacific Southwest sections. These increases are due primarily to projected declines of approximately 40% in stand diameter between 1985

Table 80.—Hardwood roundwood supplies, net annual growth, and growing stock inventory for other public ownerships, specified years 1952–1986 with projections to 2040.

Item and region	1952	1962	1970	1976	1986	2000	2010	2020	2030	2040
					Million cubic feet					
Northeast										
Roundwood supplies	23	26	28	23	23	36	39	42	44	44
Net annual growth	142	182	210	238	265	242	240	235	227	222
Inventory	3,803	4,838	5,697	6,478	9,844	12,966	15,166	17,296	19,316	21,276
North Central										
Roundwood supplies	45	51	70	72	81	103	119	135	151	151
Net annual growth	213	269	278	304	341	354	353	353	357	366
Inventory	4,583	6,619	7,649	8,343	10,112	14,200	17,050	19,780	22,380	25,020
Southeast										
Roundwood supplies	12	10	20	31	62	65	70	82	90	90
Net annual growth	27	32	55	71	81	85	80	83	97	97
Inventory	767	1,056	1,398	1,816	2,373	2,274	2,140	1,952	2,248	2,126
South Central										
Roundwood supplies	33	36	36	53	66	77	78	79	79	79
Net annual growth	55	71	90	109	101	74	71	81	96	96
Inventory	1,365	1,750	2,106	2,401	3,307	2,524	2,282	2,131	2,086	2,066
Rocky Mountains[1]										
Roundwood supplies	2	2	1	1	1	1	1	1	1	1
Net annual growth	8	9	10	11	28	15	16	14	11	12
Inventory	566	624	670	682	974	1,156	1,296	1,416	1,506	1,606
Pacific Southwest[2]										
Roundwood supplies	1	1	1	2	1	1	5	5	4	4
Net annual growth	6	5	7	7	16	5	5	4	4	4
Inventory	218	190	263	283	554	610	640	660	690	720
Douglas-fir subregion										
Roundwood supplies	5	3	9	12	35	15	16	16	16	16
Net annual growth	33	57	91	92	84	48	51	54	60	55
Inventory	1,080	1,526	2,030	2,263	2,360	2,579	2,323	2,177	2,129	2,093
Ponderosa pine subregion										
Roundwood supplies	1	1	1	1	1	1	1	1	1	1
Net annual growth	1	1	1	1	4	1	1	1	1	1
Inventory	55	58	59	59	82	100	120	146	179	223
Alaska[3]										
Roundwood supplies	([4])	([4])	4	4	6	7	7	8	8	8
Net annual growth	7	7	7	7	58	98	84	49	24	12
Inventory	3,908	3,866	3,873	3,868	1,892	2,802	3,630	4,184	4,465	4,558
United States										
Roundwood supplies	122	130	170	199	276	306	336	369	394	394
Net annual growth	492	633	750	840	977	922	901	874	877	865
Inventory	16,345	20,527	23,745	26,193	31,498	39,211	44,647	49,742	54,999	59,687

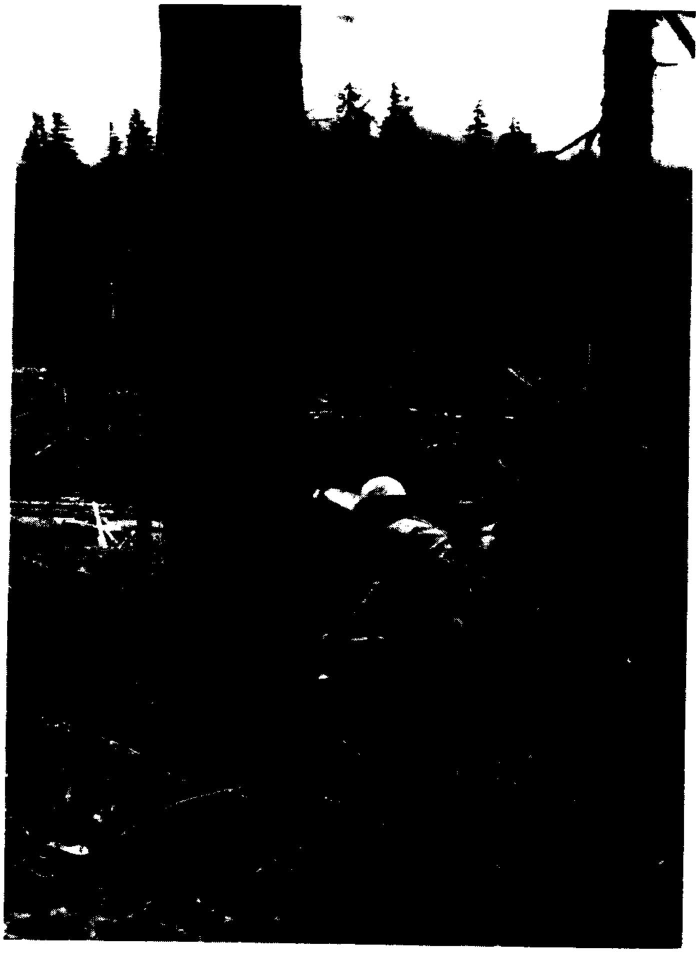
[1]*Rocky Mountains region historical data (excluding roundwood supply) includes the Great Plain states.*
[2]*PSW exludes Hawaii.*
[3]*Figures for Alaska have been revised since publication of Waddell et al. 1989.*
[4]*Less than 0.5 million cubic feet.*
Note: See table 77.
Source: See table 77.

and 2040. Declines of 25% in average stand diameter in the Rocky Mountain Region result in a 55% increase in logging costs. Logging costs in the South increase 57% over the projection period as stand diameters decline, especially during the decade following 2000.

Softwood Lumber

Softwood lumber processing includes yard handling of logs, bucking, debarking, log breakdown by primary and secondary sawing, drying, grading and preparation for shipping. Timber characteristics that influence processing costs per unit of lumber output include log diameter, length, shape, and defects. Lumber processing costs are higher in the Rocky Mountain and Pacific Coast regions, reflecting higher labor costs in these areas of the United States.

Softwood lumber processing costs (table 82) are projected to decrease in all sections and regions after 2000 (Skog, in press). This departure from the historic trend is attributable to continued improvements in saw-



Falling trees on a clear cut in the Douglas-fir subregion.

A Skagit tower with a high lead carriage system being used in steep terrain.

Table 81.—Sawtimber logging and hauling costs in the United States, by section and region, specified years 1952–1985, with projections to 2040.

Section and region	1952	1962	1970	1976	1985	Projections 2000	2010	2020	2030	2040
	1982 dollars per thousand board feet, log scale, Scribner									
South	54	74	86	70	65	72	78	84	90	102
Rocky Mountains[1]	98	96	122	154	132	156	168	180	183	204
Pacific Coast										
Pacific Northwest										
Pacific Northwest-West	93	92	107	132	120	135	144	156	153	174
Pacific Northwest-East	81	76	103	116	109	126	135	147	150	168
Pacific Southwest	79	87	97	131	115	132	141	153	153	171

[1]*Excludes North Dakota, Nebraska, and Kansas.*
Source: Adams et al. 1988.

ing technology and projected constant labor and energy costs. With labor and energy costs projected to remain constant, improvements in technology more than compensate for declining log diameters, resulting in declining processing costs. The decline between 1985 and 2040 is similar for all regions, 16% to 24%, even though diameters decrease more rapidly in the Pacific Coast (23%) than in the South (4%). Even though diameters decrease most in the Pacific Coast, the average diameter remains higher than in the South. Pacific Coast mills with larger diameter logs benefit more from the expected increase in throughput rates of future mills. Cost declines most in the Pacific Northwest-East (24%) due to a projected greater improvement in technology for board mills and a more limited decline in log diameters (13%). In the Rocky Mountains, costs decline only 16%, reflecting a slower rate of improvement in sawmilling technology.

Softwood Plywood

Softwood plywood processing involves yard handling of logs, log bucking, debarking, and peeling, veneer drying; layup and pressing; plywood grading; and preparation of plywood for shipping. Timber characteristics that influence processing costs include log diameter, log shape, defects, and specific gravity. Plywood processing costs have traditionally been highest in the Pacific Coast and lowest in the South (table 83). Higher labor costs in the Pacific Coast have been the main reason for higher processing costs there, with emphasis on grade recovery being a contributory factor.

Improved processing technology helped reduce plywood processing costs in all regions from 1952 to 1970. Softwood plywood processing costs increased from 1970 to 1976 reflecting higher labor and energy costs. Since 1976, costs have declined in all regions. This decline in softwood plywood processing costs was attributable to labor and energy costs and improved processing efficiency. The increasing share of smaller but more sound second-growth timber has also helped improve efficiency.

Plywood processing costs are projected to decline further (Spelter and Sleet 1989). With labor and energy costs constant, improvements in technology—principally the incorporation of labor saving equipment in veneer stacking, gluing, and handling—are expected to lead to declines of 4% to 7% between 1986 and 2040. The decline is greatest in the Douglas-fir subregion as the focus of production is projected to shift from sanded and specialty products to lower cost sheathing items. Accompanying this transformation is a decline in log diameters of about 25%. Processing costs in the South are projected to drop by only 5%, reflecting little change in log diameters.

Oriented Strand Board and Waferboard

Oriented strand board (OSB) and waferboard processing involves yard handling of logs, log debarking and

Table 82.—Softwood lumber nonwood processing costs in the United States, by section and region, specified years 1952–1985, with projections to 2040.

						Projections				
Section and region	**1952**	**1962**	**1970**	**1976**	**1985**	**2000**	**2010**	**2020**	**2030**	**2040**
	1982 dollars per thousand board feet									
South	60	63	76	89	89	78	78	75	72	69
Rocky Mountains[1]	74	64	84	106	96	96	96	93	87	81
Pacific Coast										
Pacific Northwest										
Pacific Northwest-West	100	85	108	112	104	105	93	93	84	81
Pacific Northwest-East	77	67	90	100	106	99	93	87	84	81
Pacific Southwest	118	101	109	120	110	99	99	93	87	87

[1] *Excludes North Dakota, Nebraska, and Kansas.*
Source: Adams et al. 1988.

Table 83.—Softwood plywood nonwood processing costs in the United States, by section and region, specified years 1952–1985, with projections to 2040.

						Projections				
Section and region	**1952**	**1962**	**1970**	**1976**	**1985**	**2000**	**2010**	**2020**	**2030**	**2040**
	1982 dollars per thousand square feet, 3/8-inch basis									
South			87	91	82	81	81	81	81	78
Pacific Coast										
Pacific Northwest										
Pacific Northwest-West	123	93	96	110	103	99	96	96	96	96
Pacific Northwest-East	120	105	76	95	81	78	78	78	78	78
Pacific Southwest		93	96	110	103	99	99	96	96	96

Source: Adams et al. 1988.

slashing, flaking, drying, gluing, forming, and pressing of flakes, and preparation of final product for shipping. OSB and waferboard processing costs are not strongly influenced by timber characteristics. Processing costs for OSB and waferboard in 1986 were higher in the North than in the South, reflecting higher labor costs in the North (table 84).

OSB and waferboard mills are already highly automated and are likely to show only minimal gains in labor productivity. Improvement in glue application resulting in reduced glue consumption is expected to be the main source of cost reductions. Declines in processing costs are projected at 7% and 4% for the North and the South.

Table 84.—Oriented strand board and waferboard nonwood processing costs in the United States, by section and region, 1986, with projections to 2040.

Section and region	1986	Projections 2000	2010	2020	2030	2040
	1982 dollars per thousand square feet, 3/8-inch basis					
North	90	84	84	84	84	84
South	87	84	84	84	84	84

Pulp and Paper

Pulp and paper processing includes wood debarking, chipping, and screening, conversion of chips into pulp using chemical or mechanical processes, mixing of pulp with additives or recycled fiber; and conversion of pulp into paper, which involves sheet formation, pressing, and drying. Pulp and paper processing may also involve recovery of pulping chemicals, bleaching of pulp fibers, and, in the case of market pulp, drying and shipping of pulp. Wood characteristics that can influence processing costs include wood density, cellulose content, resin content, and the proportion of bark or immature wood.

Pulp and paper processing costs vary among different product grades due to variations in pulping process, size of facility, different application of bleaching, and different use of recycled fiber (table 85). Processing costs for newsprint and solid bleached board in 1986 were above those for other grades, due in part to the use of smaller scale facilities. In the case of newsprint, these higher processing costs also result from higher energy costs relative to other grades. Solid bleached board processing involves bleaching which contributes to the higher cost for this grade. Unbleached kraft and semichemical board facilities are often larger in scale and involve significant cogeneration of energy, resulting in lower processing costs. Recycled board costs are low relative to other grades as they do not involve conventional pulping.

Declines of 3% and 1% are projected for newsprint and semichemical board processing costs to 2040, while unbleached kraft and solid bleached board are both projected to decrease by 20%.[24] Processing costs for recycled board are projected to remain unchanged at 1986 levels. The costs decline for unbleached kraft board is due to the adoption over time of wide-nip or high-impulse press sections, greater use of recycled fiber, and reduced energy consumption. For solid bleached board, the cost decline is attributable to improvements in bleaching technology and greater use of mechanical pulps.

[24]*Ince, Peter J.; Durbak, Irene; and Howard, James. [In preparation]. The FPL Pulpwood Model: data, assumptions, and projections to the year 2040. Madison, WI: U.S. Department of Agriculture, Forest Service. On file with: Timber Demand and Technology Assessment Research Project, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53705–2398.*

Table 85.—Nonwood processing costs at integrated pulp and paper facilities in the United States, by product, 1986, with projections to 2040.

Section and region	1986	Projections 2000	2010	2020	2030	2040
	1982 dollars per ton					
Newsprint	363	359	356	352	351	351
Unbleached kraft board	177	162	155	147	142	141
Semichemical board	206	202	204	204	204	204
Recycled board	235	235	235	235	235	235
Solid bleached board	460	398	371	370	370	370

Wood Fuel

The trend in use of wood fuel versus other fuels for home heating and industrial energy is determined by the cost of burning wood versus the cost of burning nonwood fuels. These costs are determined by equipment costs, operating costs, fuel costs, and efficiency of converting fuel to energy. Wood fuel is favored to the extent that it maintains a cost advantage over systems using nonwood fuels.

Installation costs for home wood heating systems (stoves and furnaces) increased between 1970 and 1986 in the North and Rocky Mountains, but declined in other regions (table 86). Cost increases occurred in those regions where increased demand for wood burning equipment grew faster than available supplies.

Installation costs for home heating systems are projected to decline in most regions as the demand for wood fuel declines (High and Skog, in press). Installation costs vary by region depending on the proportion of a home that is heated with wood, the changing mix of installations in single-family versus multifamily housing, and the rate of demand for wood heating systems.

Equipment costs for industrial boilers are projected to remain constant at 1986 levels (table 87). Wood boiler equipment costs are higher than costs for equipment to burn fuel oil or natural gas and about as costly as coal burning equipment. Emission control costs are projected to remain highest for coal, followed by oil, wood and

Table 86.—Residential wood stove installation costs in the United States, by section and region, specified years 1970–1986, with projections to 2040.

Region	1970	1976	1986	Projections 2000	2010	2020	2030	2040
			Thousands of 1982 dollars					
North[1]								
Northeast	.73	1.53	1.73	1.40	1.27	1.24	1.11	1.01
North Central[1]	1.16	1.20	1.78	1.24	1.21	1.20	1.08	.95
South								
Southeast	2.21	2.26	1.56	1.67	1.49	1.49	1.45	1.41
South Central	2.21	2.24	1.55	1.66	1.32	1.35	1.32	1.30
Rocky Mountains[2]	1.58	1.41	1.64	1.47	1.62	1.57	1.75	1.47
Pacific Coast								
Pacific Northwest	1.70	1.20	1.28	1.19	.90	1.69	1.56	1.52
Pacific Southwest	1.97	1.34	1.50	1.22	1.28	1.24	2.00	1.80

[1]*Includes North Dakota, Nebraska, and Kansas.*
[2]*Excludes North Dakota, Nebraska, and Kansas.*
Source: Marshall et al. 1983.

natural gas. Operating costs are also projected to remain higher for wood and coal than for oil and natural gas.

TECHNOLOGY AND RELATED ASSUMPTIONS

Technological change in wood products processing is measured by product recovery factors. Product recovery factors measure the volume of the wood product produced per unit volume of logs consumed or, in the case of pulp and paper, the volume of pulpwood or fiber consumed per ton of product produced. These factors are used to describe technological change in lumber, structural panel, and pulp and paper processing. Conversion efficiencies measure the percentage of energy recovered and are used to compare energy producing technologies for wood and alternative energy sources.

Softwood Lumber

Softwood lumber recovery has increased in all sections and regions between 1952 and 1976 (table 88). There were continued increases through 1985 in the South, Rocky Mountains, and Pacific Northwest-East. Between 1976 and 1986 recovery declined in the Pacific Northwest-West and Pacific Southwest due to a decline in average diameter of logs processed.

Table 87.—Boiler installation cost by boiler type and size, 1986.

Boiler type	Less than 100 million btu's per hour	100 million btu's or more per hour
	Thousands of 1982 dollars per million Btu per hour	
Wood	29.6	32.7
Coal	29.5	34.2
Fuel oil	3.3	8.9
Natural gas	3.0	7.7

Source: High 1985.

Softwood lumber recovery is projected to increase in all sections and regions to 2040 (Skog, in press). In the Rocky Mountains and Pacific Northwest-West, the rate of increase projected between 1985 and 2040 is less than the rate experienced between 1952 and 1976. In the South and Pacific Northwest-East where log diameter decreases are limited, technological improvements increase projected recovery (1985–2040) by 19% and 24%. The recovery increase in the Pacific Northwest-East is also due to considerable technical improvements in board mills which comprise a large portion of sawmill capacity in the region. Technology improvements yield the least recovery improvement in the Pacific Northwest-West (7%) due to a projected 23% decline in average log diameter.

Softwood Plywood

Softwood plywood recovery factors have traditionally been highest in the Pacific Northwest-East because of the larger log diameters. Softwood plywood recovery factors increased in all sections and regions between 1962 and 1985 (table 89). The largest increase occurred in the Pacific Northwest-East where an estimated 26% improvement occurred. This improvement in recovery was the result of new processing technology which allows logs to be peeled down to core diameters of three inches. Gains made in other parts of the Pacific Coast were the result of these improvements in peeling technology as well as the decreasing share of defective old-growth logs.

Softwood plywood recovery is projected to increase in all sections and regions to 2040 (Spelter and Sleet 1989). The increases range from 5% in the Pacific Northwest-West to 20% in the South. These increases reflect continued technical advances in log peeling.

Maintaining the identity of logs, such as this red alder, is a critical part of mill recovery studies.

Table 88.—Softwood lumber recovery factors in the United States, by section and region, specified years 1952–1985, with projections to 2040.

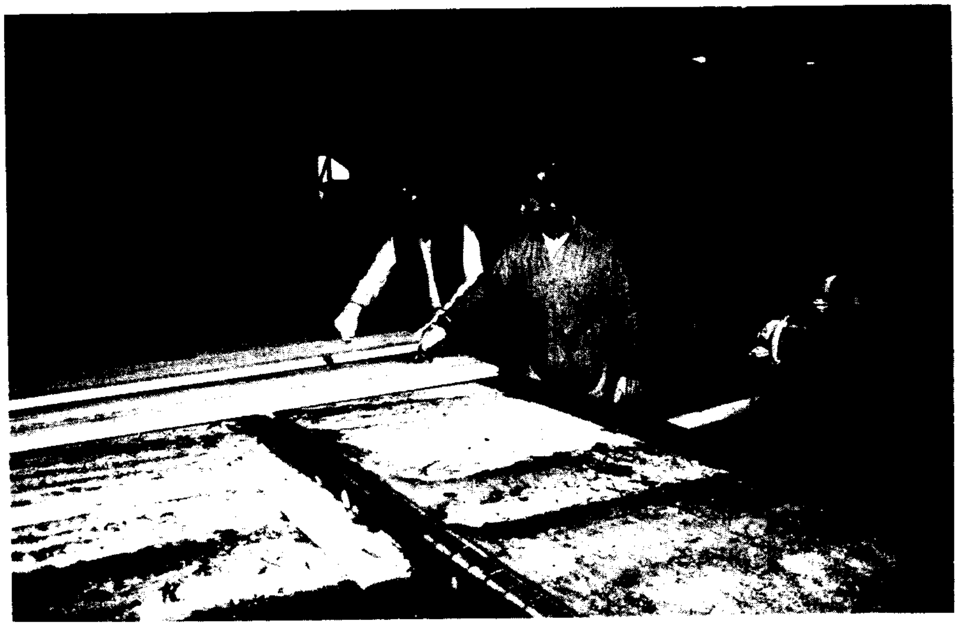
Section and region	1952	1962	1970	1976	1985	Projections 2000	2010	2020	2030	2040
	Board feet lumber tally, per cubic feet, log scale									
South	5.05	5.21	5.35	5.75	6.02	6.47	6.65	6.80	6.98	7.18
Rocky Mountains[1]	5.71	5.95	6.17	6.76	6.80	7.17	7.27	7.40	7.52	7.67
Pacific Coast										
Pacific Northwest										
Pacific Northwest-West	6.67	6.71	6.76	7.94	7.87	8.18	8.18	8.26	8.38	8.47
Pacific Northwest-East	5.41	5.46	5.49	6.02	6.33	6.74	6.97	7.23	7.51	7.82
Pacific Southwest	6.21	6.37	6.54	6.90	6.80	7.57	7.70	7.83	7.99	8.14

[1]*Excludes North Dakota, Nebraska, and Kansas.*
Source: Adams et al. 1988.

Table 89.—Softwood plywood recovery factors in the United States, by section and region, specified years 1952–1985, with projections to 2040.

Section and region	1952	1962	1970	1976	1985	Projections 2000	2010	2020	2030	2040
	Square feet, 3/8-inch basis, per cubic foot, log scale									
South		12.2	12.8	13.3	13.9	16.2	16.4	16.5	16.6	16.7
Rocky Mountains[1]		12.3	12.8	13.3	14.3	15.5	15.6	15.6	15.6	15.6
Pacific Coast										
Pacific Northwest										
Pacific Northwest-West	12.5	13.0	13.3	13.7	14.5	15.1	15.2	15.3	15.3	15.3
Pacific Northwest-East	13.3	13.7	14.3	14.7	17.2	18.8	18.9	19.0	19.0	19.0
Pacific Southwest	12.5	13.0	13.3	13.7	14.3	15.3	15.5	15.6	15.6	15.6

[1]*Excludes North Dakota, Nebraska, and Kansas.*
Source: Adams et al. 1988.



Maintaining the identity of lumber produced in the sawing phase of mill recovery studies is also a critical part of the study.

Oriented Strand Board and Waferboard

Product recovery factors in OSB and waferboard mills vary between 17 and 18 square feet (3/8-inch basis) per cubic foot, log scale (table 90). Southern recoveries are lower because a substantial proportion of the log mix is southern pine, a species that is more difficult to flake without generating high rates of reject particles.

OSB and waferboard recovery is projected to increase by only 2% to 2040 in the North and the South as improvement in flaking reduces wood loss due to production of fine sized particles. The installation of continuous presses also helps by reducing end-trim losses.

Pulp and Paper

Fiber requirements in the production of paper and board consist of varying amounts and grades of woodpulp, wastepaper and other natural fibers. These requirements depend on the grade of paper or board produced and on the production process used. Woodpulp requirements and pulping technology determine, in turn, the amount and type of pulpwood required.

Projections show the total amount of fiber required per ton of paper and board will be declining slowly (table 91).[24] This slow trend results from increased use of fillers and coatings, especially in printing and writing papers, and addition of synthetic polymer fibers to reinforce some paper and paperboard products. Total fiber use per ton of paper and board is projected to decrease 5% by 2040, to 0.977 tons.

Use of woodpulp is projected to decrease 14%, from .810 to .697 tons from 1986 to 2040, as technological developments enable greater use of wastepaper, especially in newsprint, tissue and unbleached kraft. Use of waste-

Table 90.—Oriented strand board and waferboard recovery factors in the United States, by section and region, 1986, with projections to 2040.

		Projections				
Section and region	1986	2000	2010	2020	2030	2040
	Square feet, 3/8-inch basis, per cubic foot, log scale					
North	17.9	18.3	18.3	18.3	18.3	18.3
South	16.9	17.3	17.3	17.3	17.3	17.3

Table 91.—Fiber consumption per ton of paper and board produced in the United States, specified years 1952–1986, with projections to 2040.

Year	Total	Woodpulp	Wastepaper	Other[1]
		Tons		
1952	1.080	.708	.323	.050
1962	1.029	.762	.242	.026
1970	1.021	.807	.198	.016
1976	1.004	.794	.198	.012
1986	1.025	.810	.209	.005
		Projections		
2000	0.998	.785	.210	.002
2010	0.988	.764	.222	.002
2020	0.978	.730	.246	.002
2030	0.976	.709	.267	(2)
2040	0.977	.697	.280	(2)

[1]*Includes cotton linters, rags, bagasse, straw, kenaf, etc.*
[2]*Less than .001 tons.*
Note: Data may not add to totals because of rounding.
Source: Ulrich 1989.

paper is projected to increase 34%, to .280 tons by 2040. Use of other natural fibers is projected to fall below .001 tons by the year 2040, when fiber use will consist of, on average, 71% woodpulp and 29% wastepaper.

Use of pulpwood per ton of woodpulp produced has been decreasing slowly during the past few decades (table 92). In 1986, an average of 1.504 cords of pulpwood were used to produce one ton of pulp. Use of pulpwood is projected to continue decreasing as high-yield mechanical pulps replace chemical pulps, which have lower yields and therefore require more pulpwood. By the year 2040 use of pulpwood is projected to average 1.362 cords per ton of woodpulp.

The large increase in the use of hardwoods relative to softwoods has contributed to lower pulpwood requirements since hardwoods have a higher pulp yield. Hardwoods increased from 14% of total pulpwood use in 1952, to 31% in 1986. Hardwood use is projected to increase further with wider adoption of improved paper pressing technology and increased use of modern mechanical pulping processes which can incorporate more hardwood fiber. Hardwoods are projected to comprise 41% of total pulpwood use by the year 2040.

Table 92.—Pulpwood consumption per ton of woodpulp produced and percent consumption of softwood and hardwood pulpwood in the United States, specified years 1952–1986, with projections to 2040.

Year	Pulpwood consumption per ton of wood-pulp produced	Consumption: Softwood pulpwood	Consumption: Hardwood pulpwood
	Cords	*Percent*	
1952	1.606	85.6	14.4
1962	1.579	77.6	22.4
1970	1.552	75.9	24.1
1976	1.509	74.8	25.2
1986	1.504	69.2	30.8
	Projections		
2000	1.488	63.3	36.7
2010	1.459	59.9	40.1
2020	1.428	59.7	40.3
2030	1.411	59.4	40.6
2040	1.362	59.2	40.8

Sources: Pulpwood consumption: Ulrich 1989. Percent softwood and hardwood pulpwood, 1952 and 1962: American Paper Institute 1970. Percent softwood and hardwood pulpwood, 1970, 1976, and 1986: USDC BC 1970, 1976a, 1986.

Wood Fuel

Efficiency of home wood burning increased substantially between 1970 and 1986 with increased use of airtight stoves and fireplace inserts (table 93). The average efficiency of wood heating equipment is projected to improve relative to nonwood systems though 2000. Wood burning efficiency is expected to improve as more wood stoves sold meet new national performance standards set by the U.S. Environmental Protection Agency (High and Skog, in press). Relative wood burning and nonwood system efficiencies are projected to remain constant after 2000.

Conversion efficiencies for industrial boilers are projected to remain constant at 1986 levels (table 94). Boiler conversion efficiency is projected to remain higher for coal, oil, and natural gas than for wood.

Table 93.—Efficiency of residential heating equipment, specified years 1970–1986, with projections to 2040.

Heating equipment	1970	1976	1986	Projections: 2000	2010	2020	2030	2040
				Percent energy recovered				
Wood stoves	30	51	57	60	60	60	60	60
Electric furnances	95	95	95	95	95	95	95	95
Fuel oil furnaces	50	50	56	65	65	65	65	65
Natural gas furnaces	60	60	63	65	65	65	65	65

Source: Marshall 1981.

Table 94.—Efficiency of boilers by type and size, 1986.

Boiler type	Less than 100 million btu's per hour	100 million btu's or more per hour
	Percent energy recovered	
Wood	62	67
Coal	72	80
Fuel oil	82	83
Natural gas	82	83

Source: Van Wie 1983

CHAPTER 7. PROJECTED TIMBER DEMAND/SUPPLY RELATIONSHIPS

The preceding chapters of this assessment have been largely concerned with assessing the current situation and with the development of the various assumptions needed to project the demand for timber on domestic forests, and the supply of timber that would be available for harvest. One of the primary objectives of this study is to use these assumptions to project prospective changes in the Nation's timber resource. Projections of changes in timber supplies, removals, growth, and inventories, along with projections of timber demands, provide a means of identifying developing and future timber supply/demand situations. These projections help shape our collective perceptions that, in turn, influence stewardship and industrial decisions in the next decade. Finally, projections also provide the data base needed for analyzing the economic, social, and environmental implications of a range of policy and program options.

These projections derive directly from the assumptions regarding major determinants of changes in demand and the timber resource described in Chapter 6. The projections will change as these assumptions are modified. Further, there is no intent to portray the projected trends as socially or economically desirable. Indeed, the economic, social, and environmental implications associated with these trends may stimulate actions to change them.

In this analysis, all projections are made at equilibrium price levels.[25] That is, prices and production factors are allowed to change until the quantities supplied and demanded are equal.

The purpose of this chapter is to present the projections of future market activity for both product and stumpage markets. The first section contains a discussion of the consumption and prices for major forest products. The next section describes harvest and price levels in the stumpage markets. The third section presents the economic and environmental implications of the base projections of resource changes.

PROJECTED CONSUMPTION, PRODUCTION, TRADE AND PRICES FOR TIMBER PRODUCTS

Based on the projections and assumptions about the major markets discussed earlier, consumption, production, and prices for various forest products are projected to follow somewhat diverse trends over the next five decades. In this section, projections of consumption by end use are presented for the solid-wood products (lumber, structural panels, and nonstructural panels). For all products, net trade is the difference between consumption and production.

[25] *In this study, equilibrium prices and quantities are determined by the intersection of supply and demand curves. The equilibrium prices are those prices at which the amount willingly supplied and the amount willingly demanded are equal. These prices and the associated equilibrium timber supply/demand projections were developed by means of regionally desegregated economic simulation models. For further details, see: Adams and Haynes (1980), Haynes and Adams (1985), and Binkley and Cardellichio (1986).*

Lumber

Lumber consumption in all uses in 1986 was 57.2 billion board feet (table 95). This was almost 40% above average consumption in the 1950s and 1960s, and 10% more than the previous high, 52.1 billion, reached in 1978. Consumption of lumber is projected to rise throughout the projection period, reaching 70.0 billion board feet in 2040. The most rapid increases occur early in the next century, as the use of softwoods in construction and hardwoods in manufacturing and shipping continue to increase at relatively high levels. After 2020, declining use in housing is more than offset by continued growth in nonresidential consumption of both hardwood and softwood. This is especially the case for the last decade of the projection where the greatest growth in consumption is for manufacturing purposes.

In 1986 softwood species comprised nearly 82.3% of all lumber consumed and this percentage is expected to change relatively little over the projection period. In some end uses of lumber, such as shipping (pallets) and manufacturing (furniture), a slow increase in the proportion of hardwoods is expected.

Trade in lumber products is dominated by softwood lumber imports from Canada (table 96). Between 1952 and 1986, softwood lumber imports (nearly all from Canada) rose from 2.3 billion to 14.3 billion board feet; however, a large part of this increase has taken place over the past decade. Projections show a decline by 2000 to 10.2 billion board feet. After 2000, imports from Canada start to rise. Softwood lumber imports peak around 2020 and fall to 9.3 billion board feet by 2040. Hardwood lumber imports are expected to remain constant throughout the next five decades.

Like softwood lumber imports, softwood lumber exports have increased since the early 1950s. Most of the growth has consisted of shipments to Japan, South and Central America, and Western Europe. Softwood lumber exports are expected to be stable after 2020. Hardwood lumber exports have also grown and are expected to stabilize at about 600 million board feet.

Production of lumber in the United States shows continued growth (table 96). In the near term, expansions in softwood production outpaces that for hardwood lumber. In percentage terms, however, increases in hardwood lumber production outpace those for softwood lumber. The projections reflect a steady drop in the Canadian share because of relatively more rapid cost increases in Canada.

Projections of regional production of softwood lumber are shown in table 97. These projections show a dynamic and increasing industry, with lumber production

Table 95.—Lumber consumption in the United States, by species group, end use, specified years 1962–1986, with projections to 2040.

		Species group		End use					
Year	Total	Softwoods	Hardwoods	New housing	Residential upkeep & improvements	New nonresident construct	Manufacturing	Shipping	All other
						Billion board feet			
1962	39.1	30.8	8.5	14.5	4.4	4.2	4.5	4.6	6.9
1970	39.9	32.0	7.9	13.3	4.7	4.7	4.7	5.7	6.8
1976	44.7	36.6	8.0	17.0	5.7	4.5	4.9	5.9	6.7
1986	57.2	47.1	10.1	19.3	9.9	5.3	4.8	6.8	11.1
2000	55.4	45.5	10.0	12.9	12.8	6.6	7.0	6.1	10.0
2010	61.0	49.7	11.3	13.8	14.5	7.2	7.6	7.3	10.7
2020	66.5	54.3	12.2	15.2	15.9	7.9	8.3	7.9	11.3
2030	68.2	55.3	12.9	13.5	16.7	8.7	9.1	8.6	11.7
2040	70.0	56.7	13.2	12.0	17.0	9.5	10.1	9.0	12.4

Note: Data may not add to totals because of rounding.

Table 96.—Lumber consumption, imports, exports, and production in the United States, specified years 1960–1986, with projections to 2040.

	Consumption			Imports			Exports			Production		
Year	Total	Softwood lumber	Hardwood lumber	Total	Softwood lumber[1]	Hardwood lumber	Total	Softwood lumber[1]	Hardwood lumber	Total	Softwood lumber	Hardwood lumber
						Billion board feet						
1960	37.7	29.6	8.1	3.9	3.6	.3	.9	.7	.2	34.7	26.7	8.0
1970	39.9	32.0	7.9	6.1	5.8	.3	1.2	1.1	.1	35.0	27.3	7.7
1976	44.7	36.6	8.0	8.2	8.0	.3	1.8	1.6	.2	38.3	30.3	8.0
1986	57.2	47.1	10.1	14.6	14.3	.3	2.4	1.9	.5	45.0	34.7	10.3
2000	55.2	45.3	9.9	10.5	10.2	.3	3.1	2.5	.6	47.9	37.7	10.0
2010	60.8	49.5	11.3	12.8	11.9	.3	3.1	2.5	.6	51.6	40.0	11.0
2020	66.0	53.9	12.1	13.5	12.8	.3	3.2	2.6	.6	56.2	43.8	12.0
2030	67.7	54.8	12.9	10.5	10.2	.3	3.2	2.6	.6	60.4	47.2	13.9
2040	69.4	56.2	13.2	9.6	9.3	.3	3.2	2.6	.6	63.0	49.5	13.0

[1]*Includes small volumes of mixed species not classified as softwoods or hardwoods.*
Note: Data may not add to totals because of rounding.

shifting among regions largely in response to changes in relative costs.[26] The primary cost that drives these shifts is that for raw material (stumpage). There is, for example, an initial shift in softwood lumber production from the Pacific Coast regions to those in the South. By 2040, the South has increased its share of lumber production to 40% while the share of the Pacific Coast regions drop to 38%. The initial drop within the Pacific Coast regions, results from rising stumpage costs (relative to other regions) associated with roughly stable timber inventories in the Douglas-fir subregion and declining private inventories in the Pacific Southwest. Softwood lumber production in the northern regions and in the Rocky Mountains rises through the projection period, and substantially so in the Rocky Mountains. The growth in the Rocky Mountains is fueled by the assumed increases in national forest harvest (table 77). These increases are sufficient to slow the rate of growth in stumpage prices.

The regional projections of hardwood lumber production shift in response to changing cost conditions. Most of the increase in hardwood lumber production is in the North. By 2040, 72% of hardwood lumber is produced in the North. Production in the South remains roughly stable until 2020 and then declines because of declines in hardwood inventories.

[26]*In these projections, expansion and contraction of softwood lumber production and imports were determined by current profit margins (as measured by the difference between prices and total production costs) realized in each producing region relative to historical levels. Production cost disadvantages faced by domestic regions stem both from rising stumpage and nonwood costs. The increases in production costs (fueled by rapidly increasing stumpage prices) and attendant reductions in profit margins are particularly important determinants of downward capacity adjustments in the Pacific Coast regions during the first decade of the projection period.*

Structural Panel Products

Structural panels (softwood plywood and oriented strand board and waferboard) consumption reached 26 billion square feet (3/8-inch basis) in 1986—83% above the volume consumed in 1970 and nearly 3 times total use in 1962 (table 98). Until the late 1970s, softwood ply-

Table 97.—Lumber production in the contiguous states, by softwoods, hardwoods, and region, specified years 1952–1986, with projections to 2040.

Species group & region	1952	1962	1970	1976	1986	Projections 2000	2010	2020	2030	2040
						Billion board feet, lumber tally				
Softwoods										
Northeast	1.3	0.9	0.6	0.9	1.4	1.8	2.2	2.5	2.6	2.8
North Central[1]	0.4	0.3	0.3	0.5	0.3	0.5	0.7	0.9	1.0	1.1
Southeast	5.2	2.7	2.8	3.5	5.2	6.2	6.8	7.5	7.0	6.7
South Central	3.6	3.2	4.2	4.7	6.1	6.9	6.4	8.3	11.0	13.4
Rocky Mtn.	2.5	3.6	4.2	4.6	4.5	5.4	6.0	6.2	6.3	6.5
Pacific NW[2]										
Douglas-fir subregion (Western Oregon & Western Washington)	10.3	8.6	7.4	8.4	9.2	9.1	9.4	9.6	10.5	10.5
Ponderosa pine subregion (Eastern Oregon & Eastern Washington)	2.3	2.4	2.3	2.8	2.8	3.3	3.9	4.3	4.5	4.6
Pacific SW[3]	4.6	5.0	5.1	4.9	5.1	4.6	4.8	4.5	4.3	4.0
Total U.S. Softwoods	30.2	26.6	26.9	30.3	34.6	37.8	40.2	43.8	47.2	49.6
Hardwoods										
Northeast	0.9	1.0	1.4	1.9	2.2	2.8	3.1	3.9	4.5	4.8
North Central[1]	2.4	1.2	1.5	2.6	3.1	3.3	3.8	4.2	4.6	4.9
Southeast	1.6	1.5	1.7	1.4	2.0	1.7	1.7	1.6	1.4	1.1
South Central	2.3	2.6	2.5	1.8	2.6	2.3	2.4	2.4	2.5	2.6
West	([4])	0.1	0.1	0.3	0.4	0.2	0.2	0.2	0.2	0.2
Total U.S. Hardwoods	7.2	6.4	7.2	8.0	10.3	10.3	11.5	12.3	13.2	13.5

[1]*The Great Plains are included in the Northcentral region.*
[2]*Excludes Alaska.*
[3]*Excludes Hawaii.*
[4]*Less than 50 million board feet.*
Note: Data may not add to totals because of rounding.

Table 98.—Structural panel consumption in the United States, by panel type, end use, specified years 1962–1986, with projections to 2040.

Year	Total	Panel type: Softwood plywood	OSB/waferboard	End use: New housing	Residential upkeep & improvements	New nonresident construct	Manufacturing	Shipping	All other
				Billion square feet (3/8-inch basis)					
1962	9.5	9.5	([1])	4.0	1.0	1.7	0.7	0.2	1.9
1970	14.2	14.2	([1])	5.6	2.4	1.9	0.9	0.3	3.2
1976	18.0	17.7	0.2	7.8	3.3	1.9	1.1	0.3	3.6
1986	26.0	21.7	4.3	10.0	6.2	3.1	1.3	0.4	5.1
2000	25.6	17.3	8.3	7.0	8.0	4.7	2.9	1.8	1.1
2010	28.9	18.2	10.7	7.9	9.2	5.3	3.6	2.0	0.8
2020	33.0	20.1	13.0	9.2	10.4	6.0	4.3	2.5	0.7
2030	35.6	21.3	14.4	8.4	11.3	6.8	5.3	3.2	0.7
2040	39.2	23.2	16.0	7.6	12.2	7.7	6.5	4.4	0.9

[1]*Less than 50 million square feet.*
Note: Data may not add to totals because of rounding.

wood was the only structural panel in wide use; and primarily because of its substitution for softwood lumber, its growth was particularly fast in the 1950s and 1960s. With the introduction of oriented strand board and waferboard and their subsequent substitution for softwood plywood, however, consumption of those products have increased rapidly slowing the growth in the use of softwood plywood.

Projections of total structural panel consumption rise to 39.2 billion square feet in 2040, about 50% above 1986 consumption (table 98). Most of the increase over the projection period is due to continued growth in orient-